Developing an effective speed limit compliance intervention for Nigerian drivers

A study of drivers who work in a fleet company with strong safety culture

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The candidate confirms that the work submitted is his/her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Travelling at illegal and/or inappropriate speed continues to be the single biggest factor in road traffic crashes and fatalities in Nigeria. Existing evidence suggests that drivers, particularly those who work in companies with strong safety culture exhibit different sets of speeding attitudes and behaviours in work and private driving. This research is based on the premise stated above, and the lack of speed related research in Nigeria. Using Ajzen's Theory of Planned Behaviour (TPB: Ajzen, 1991), this thesis investigates the socio-cognitive determinants of speeding behaviour of drivers' in their work and personal vehicles. It also seek to test and evaluate the efficacy of two speed limit compliance interventions on driver behaviour and safety. Using a multi-method approach, four independent but related studies were carried out. Study 1, a qualitative study hinged on the TPB, elicited the salient beliefs drivers' held towards speeding. Study 2, a quantitative study inspired by the TPB was used to investigate differences in drivers' attitudes, and self-reported behaviour in their work and private vehicles. It also measured the effects of the interventions on the TPB constructs. Study 3, an experimental study, tested the efficacy of a smartphone-based advisory Intelligent Speed Assistance (ISA) application, and TPB-based Speed Awareness Course (SAC) on drivers' speed choice. Study 4, a prospective survey, examines the acceptability of ISA using the Unified Theory of Acceptance and Use of Technology (UTAUT: Venkatesh et al., 2003).

The results provided greater understanding into a range of salient beliefs influencing the speeding behaviour of Nigerian drivers which are peculiar to the socio-cultural context. The findings show the TPB model explained up to 24% of the variance in Intention to comply with speed limits. As predicted, participants reported a higher Intention to comply with speed limits in their work than private vehicle. Drivers' attitude emerged as the most significant predictor and strongest correlate with Intentions to comply with speed limit in both work and private vehicle. The TPB was also applied to evaluate changes in drivers' speeding cognition following experience with the ISA and the speed awareness course. There was no evidence of any substantial changes to any of the TPB constructs following short-term experience with the ISA, and speed awareness course. Also, investigation of the relationship between TPB variables and observed speeding behaviour suggests that higher levels of drivers' Intentions toward speed limit compliance and Strong Perceived Behavioural Control are correlated with lower levels of objectively measured speeding behaviour. Further, the dichotomous groups of low Intenders and high Intenders had significant differences in their observed speed, with the former more likely to engage in speed limit violations.

Findings from the ISA and SAC intervention with regards to speed choice and safety, revealed significant reductions in speed violation, reduced mean speeds and speed variability. The findings have important theoretical and applied implications for development of better speed limit compliance interventions improve driving behaviour, and general road safety.

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Abbreviations

ADAS: Advanced Driver Assistance Systems

DBQ Driver Behaviour Questionnaire

FRSC: Federal Road Safety Corps

GDP: Gross Domestic Product

GNP: Gross National Product

HBM: Health Belief Model

HIC: High Income Countries

ISA: Intelligent Speed Assistance

LMIC: Low and Middle Income Countries

PBC: Perceived Behavioural Control

PCA: Principal Component Analysis

PDAS: Percentage distance travelled above the speed limit

RTC: Road Traffic Crashes

SAC: Speed Awareness Course

SPDC: Shell Petroleum Development Company

TPB: Theory of Planned Behaviour

UTAUT: Unified Theory of Acceptance and Use of Technology

WHO: World Health Organization

Chapter 1: Introduction

1.1 Overview

In Chapter one of this thesis the extent of the global problems associated with road traffic accidents and their over-representation in Low-and-Middle income countries is reviewed. The chapter also explores the past and current road traffic safety situation in Nigeria, and compares it with other developing and developed nations. The contributing factors to road traffic crashes are also examined.

1.2 Global road safety

The problem of injuries and fatalities as a result of Road Traffic Crashes (RTCs) is now acknowledged to be a global issue, with authorities in virtually all countries of the world concerned about the growth in the number of people killed and seriously injured on their roads (Jacobs et al., 2000). RTCs are becoming a world epidemic, with heavy negative impacts on diverse sectors of nation's economy and the ubiquitous loss of lives.

Every year approximately 1.25 million people die (equivalent to over 3450 deaths every day) and an extra 50 million people are injured or become disabled from road traffic crashes in the world (WHO, 2015; WHO, 2013a; WHO, 2009). The UK Transport Research Laboratory, in its 2000 report estimated the annual burden of economic costs globally for RTCs at around US$ 518 billion, which according to a WHO report on road traffic injury prevention is 1% of gross national product (GNP) in developing (low-income) countries, 1.5% in countries in economic transition (middle-income) and 2% in highly-motorized (high-income) countries.[1] (Jacobs et al., 2000; WHO, 2004).

In 2004, road traffic injuries were ranked as the ninth leading cause of death at 2.2% three places below HIV/AIDS at 3.5%. It has been forecasted to be the fifth leading cause of death by year 2030, at 3.6%, five places above HIV/AIDS, which will then be 2.0% (WHO, 2009), see Figure 1. The WHO has also predicted that traffic fatalities will be the second leading cause of disability-adjusted life-years lost in developing countries by the year 2020 (cited by Koptis & Cropper, 2005).

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[1] The World Bank classification of economies based on gross national income (GNI) per capita.
Low Income: less than $1,005
Lower-middle income: $1,006 – 3,955
Upper-Middle Income : $3,956 - $ 12,235
High Income: Greater than $12,235.
Nigeria belongs to the Lower-Middle income class with a GNI/capital of $2,080.

TOTAL 2004

RANK	LEADING CAUSE	%
1	Ischaemic heart disease	12.2
2	Cerebrovascular disease	9.7
3	Lower respiratory infections	7.0
4	Chronic obstructive pulmonary disease	5.1
5	Diarrhoeal diseases	3.6
6	HIV/AIDS	3.5
7	Tuberculosis	2.5
8	Trachea, bronchus, lung cancers	2.3
9	Road traffic injuries	2.2
10	Prematurity and low birth weight	2.0
11	Neonatal infections and other	1.9
12	Diabetes mellitus	1.9
13	Malaria	1.7
14	Hypertensive heart disease	1.7
15	Birth asphyxia and birth trauma	1.5
16	Self-inflicted injuries	1.4
17	Stomach cancer	1.4
18	Cirrhosis of the liver	1.3
19	Nephritis and nephrosis	1.3
20	Colon and rectum cancers	1.1

TOTAL 2030

RANK	LEADING CAUSE	%
1	Ischaemic heart disease	12.2
2	Cerebrovascular disease	9.7
3	Chronic obstructive pulmonary disease	7.0
4	Lower respiratory infections	5.1
5	Road traffic injuries	3.6
6	Trachea, bronchus, lung cancers	3.5
7	Diabetes mellitus	2.5
8	Hypertensive heart disease	2.3
9	Stomach cancer	2.2
10	HIV/AIDS	2.0
11	Nephritis and nephrosis	1.9
12	Self-inflicted injuries	1.9
13	Liver cancer	1.7
14	Colon and rectum cancer	1.7
15	Oesophagus cancer	1.5
16	Violence	1.4
17	Alzheimer and other dementias	1.4
18	Cirrhosis of the liver	1.3
19	Breast cancer	1.3
20	Tuberculosis	1.1

Figure 1: Leading causes of death, 2004 and 2030 compared (Source: WHO, 2009)

While there has been a downward trend in road traffic fatalities in some high-income countries as a result of various countermeasures put in place, the situation is different in developing nations such as Nigeria, where limited resources and attention has been paid to this growing problem. For example, high-income countries such as Sweden, UK, the Netherland, and Japan have managed to reduce road traffic fatality rates in the recent decade from levels varying between 5.2 and 6.5 to currents rates of 2.8 and 4.7 deaths per 100, 000 population. Road traffic fatalities in developing nations like Nigeria are on the rise. (WHO, 2015). Figure 2 shows the downward trends in road traffic fatalities that began in the 1970s and 1980s in some selected high-income countries. However, the numbers have since begun to plateau, indicating the need for extra interventions.

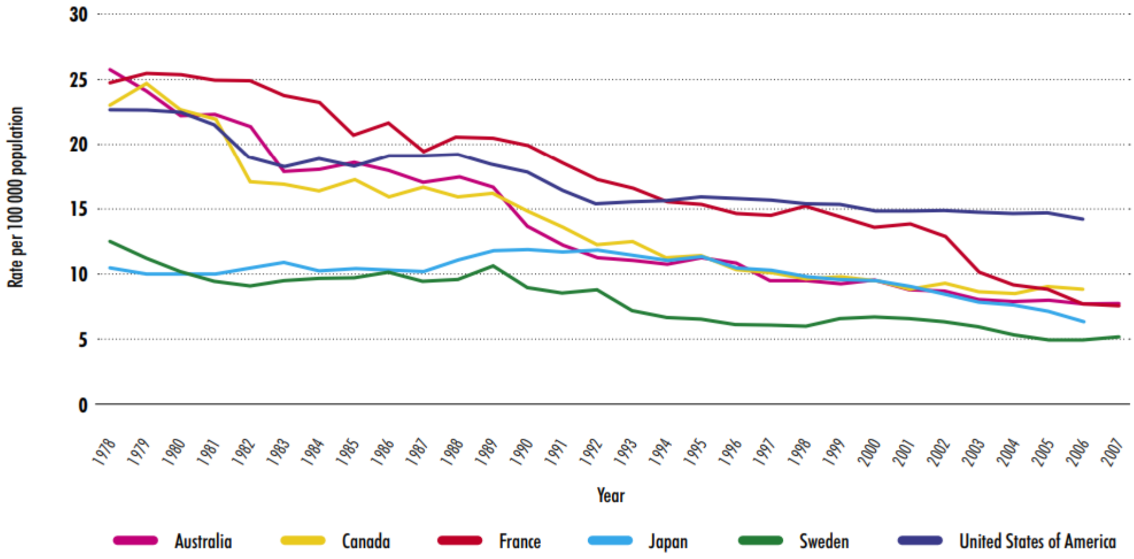

Figure 2: Trends in road traffic fatality in selected high income countries. Source, WHO, 2009)

In its Global status report on road safety 2015, the World Health Organisation (WHO) reports that the highest road traffic fatality rates are in the Low-and Middle-Income countries (LMICs), with 90% of road traffic deaths. Ironically, the LMICs have only half of the world's registered vehicles, so that there is a clear disproportionately high burden of road fatalities, relative to their level of motorization.

Road traffic injuries have become a major cause of Disability-Adjusted Life Year (DALY)[2] losses in LMICs, because many children and men in their productive ages suffer these injuries (Benner et al., 2006), and the fatality rates in these countries was estimated to increase by 80% from 1990 to 2020, unless appropriate measures were taken (Bishai et al., 2008).

What stands out here is that, the African region, which is the least motorised region of the world, possessing only 2% of the world's vehicles, has the highest rate of road fatalities of 26.6 deaths per 100,000 population (see Figure 3) compared with the global average of 17.4 death per 100,000 population, and contributing to 16% of global deaths. According to Chen (2010), factoring Africa's low vehicle ownership, the traffic fatality

2 DALY: A World Health Organization summary measure used to give an indication of overall burden of disease in a population.

rate in African countries ranges from 10-fold to more than 100-fold those in the United States.

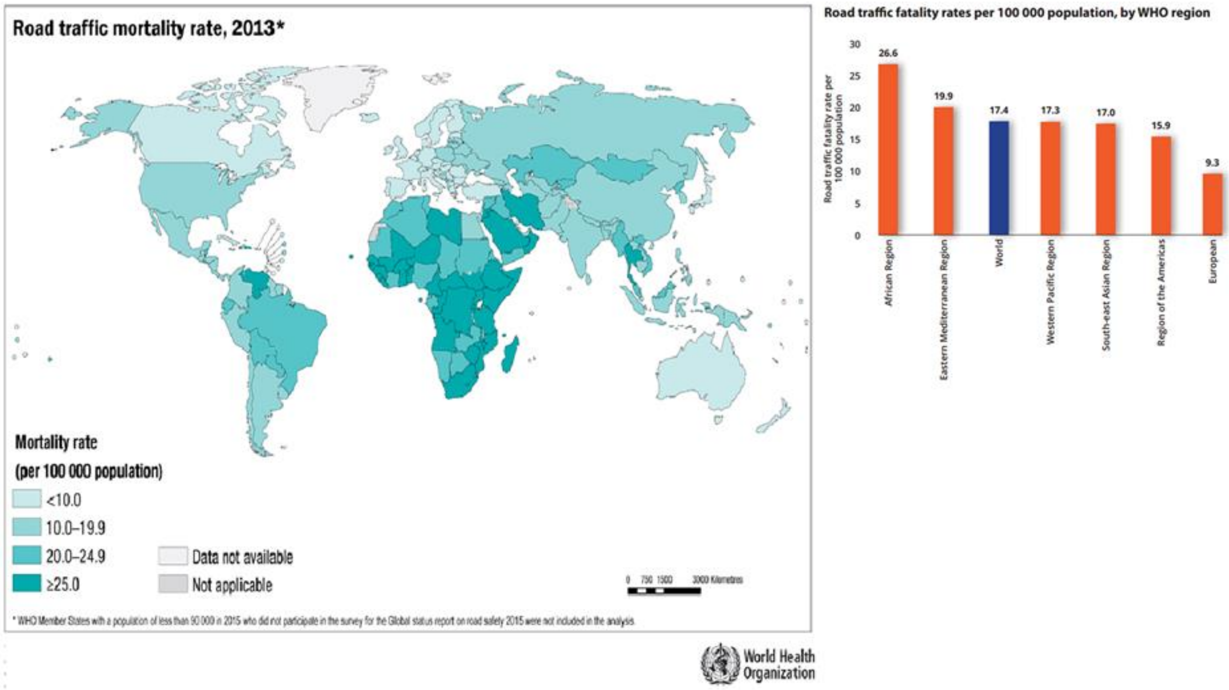

Figure 3: A comparison of global road fatalities (Source: WHO, 2013a)

Rapid motorisation, poor road and traffic infrastructure as well as the behaviour of road users, have all contributed immensely to the increase in road traffic crashes and fatalities in Africa. This increase was estimated at 80% between years 2000-2020, unless very serious countermeasures and interventions were put in place (Peden et al., 2004).

Road traffic crashes are largely preventable and predictable; it is a human made problem, and amenable to rational analysis, and countermeasure (WHO, 2004). While many countries have taken positive steps towards improving the institutional framework needed to support road safety, many challenges remain (WHO, 2004). According to the WHO, only one-third of world countries have a national road safety framework endorsed by the government, that includes specific targets and that has funding allocated for its implementation (WHO, 2009).

Improving safety in road transport is a policy imperative, given the number of death and injuries caused yearly. A multifaceted approach by every country is required, involving legislative, educational, engineering, and other measures. Safety has to be addressed in all aspects of the design, operation and interfacing of the transport system – affecting road users, vehicles and the corresponding infrastructure.

The UN has proclaimed the period 2011-2020 as the Decade of Action for Road Safety, "with a goal to stabilize and then reduce the forecast level of road traffic fatalities around the world by increasing activities conducted at the national, regional and global levels". As more countries begin or continue to take steps towards addressing their national road safety problem, it has become apparent that regular research, as well as assessment and evaluation of road safety schemes are needed.

1.3 The road safety profile of Nigeria

1.3.1 Introduction

Nigeria has an estimated population of over one hundred and seventy million people (140,431,790 in the 2006 national census). It is the most populous African nation, and is the world's seventh most populated country. The annual growth rate between 1991 and 2006 was 2.8%. According to the 2006 census, the population is equally divided between males and females and is distributed into, in rural and urban areas at about 51.7% and 48.3% respectively (National Bureau of Statistics, 2012).

According to the World Bank, Nigeria's gross domestic product (GDP) in 2013 stood at $521.8 billion, with GDP growth rate of 5.4%. However, declining oil revenues from weaker oil prices has put the economy under pressure, with the value of its currency decreasing.

With a moribund rail system, and high cost of air travel, road transportation is the most commonly used mode of transport in Nigeria (Ukoji 2014; Sumaila, 2013; Odeleye 2000). This is because it is the most affordable and accessible mode to the populace; thus making the roads heavily motorised and leading to overdependence, and much pressure on the available road infrastructure. With a poor public transport system, the car ownership rate has been on the increase in recent years. Many car owners find it more convenient to travel with their cars rather than public transport in congested conditions (Ukoji, 2014; Odeleye 2000).

Road transport accounts for over 90% of the subsector contribution to the gross domestic product. With a total of 193,200km of roads (Paved: 28,980km and Unpaved: 164,220km) (KPMG, 2014). Nigeria has the largest road network in West Africa and the second largest south of the Sahara. According to the World Health Organisation (2013a), there are approximately over 12 million registered vehicles plying Nigeria's roads, at 85 cars per 1000 people. It has a population-road ratio of 860 persons per square kilometre, indicating intense traffic pressure on the available road network (Ukoji, 2014).

In spite of concerted efforts at reducing RTCs such as establishment of the Federal Road Safety Corps (FRSC), which is a government agency with statutory responsibilities for road safety administration, road safety educational campaigns by government agencies and charities, engineering solutions (e.g. speed humps and road signs) on roads with high risk of crashes, Nigeria has consistently featured among the countries with a high number of crashes in the past decade. Although there is a level of high under-reporting of road traffic crashes in Nigeria, it still has the highest road safety fatalities in Africa, and is ranked among the top four countries with high road traffic crashes in the world. Nigeria has an estimated annual road traffic death rate of 33.7 per 100,000 population, with one in every four road accident deaths in Africa (WHO, 2013a).

RTCs have been described as the second leading cause of violent death after deaths from the Boko Haram crisis in the North east of the country (Ukoji, 2014), and remained prevalent with seasonal epidemics[3]. Between the period 2000 – 2016, RTCs claimed 481,703 casualties, including 97,161 fatalities and 383,684 serious injuries (FRSC, 2010-2016).

The socio-economic cost of road traffic crashes in Nigeria is devastating, with direct loss according to Adekunle (2012a), only understood in terms of the labour lost to the nation’s economy, which consequently results in reduced productivity. Other costs include the emotional and related cost to families, and disabled victims. Labinjo et al. (2010) in an epidemiological study in the 36 states of Nigeria surveyed 3082 people, of whom 127 had sustained injuries from road traffic crashes. They found that 29% of those with injuries suffer some form of disability, with 13.5% of them unable to return to their jobs. According to the WHO (2013a), Nigeria loses about US$20 Billion yearly (4% of its GDP) from road traffic crashes, giving an idea how dangerous Nigerian roads are. To better understand the road safety situation in Nigeria**,** there is a need to compare data with other developing, emerging and developed nations (see Figure 4).

[3] Seasonal Epidemics: Fatal accidents happen more during festive and seasonal periods. because of the various festivities lined up during this period, which involve much more travelling than usual. Example during Christians Christmas (December and Easter (April) and also during Islamic holidays.

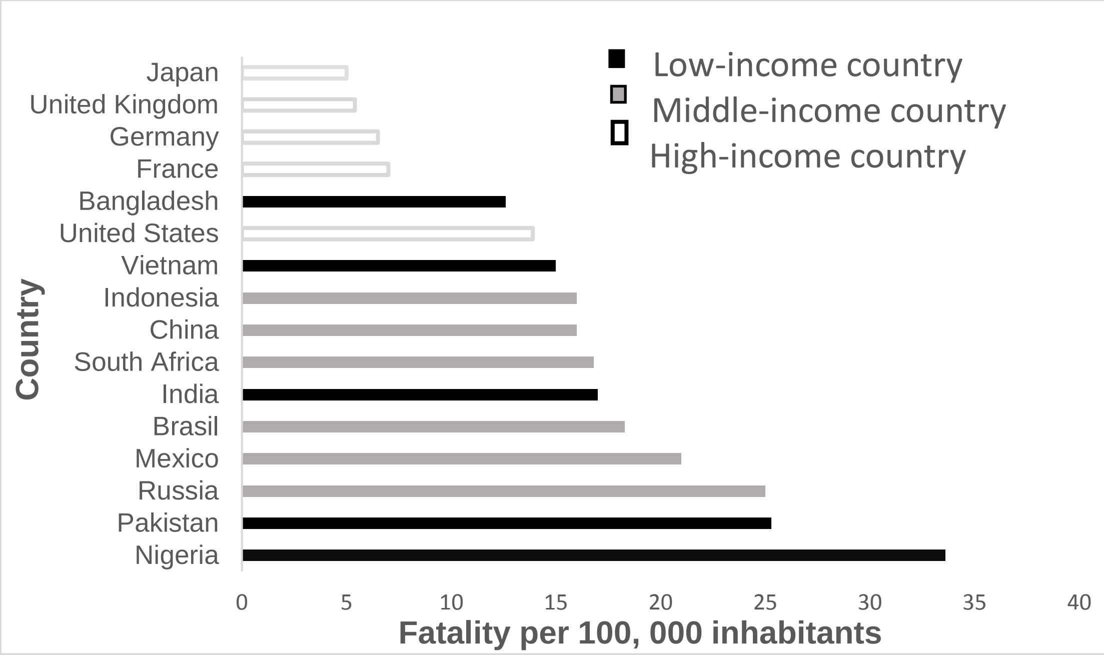

Figure 4: Traffic fatality per 100,000 inhabitants in various countries (Adapted from WHO, 2013a; WHO, 2009)

1.3.2 Contributory factors to road crashes in Nigeria

The cause of road traffic crashes in Nigeria are quite multi-factorial, and sometimes involve the interaction of human, vehicular and road/environmental components (Atubi, 2012). Crash investigation in Nigeria, as in most developing nations is conducted mainly by the Police or Federal Road Safety Corp (FRSC)[4], mostly focussing on litigation issues.

Whilst there seem to have been a relative improvement in RTC data collection in the past years, there are still challenges associated with data reliability and under reporting. Road traffic crash data in Nigeria has shown great variation in terms of number of crashes and deaths over the past decade. Adekunle (2012b), associates the road safety fluctuation in fatalities and casualties with the economic climate of the country. He argues that the period 1975-1983 represented the period of economic boom in the country with the oil prices soaring high, leading to increases in vehicle ownership and vehicular movements and consequently more crashes and loss of lives. On the other hand the period 1983- 1999 represents the period of economic recession in the country (the height of military dictatorship), with resulting austerity and a reduction in mobility on Nigerian roads. With the return of democracy in 1999, the number of crashes have

[4] FRSC: is the Government Agency with statutory responsibilities for road safety administration in Nigeria. It was founded in 1988.

been steadily on the rise. These fluctuations may in part reflect the unreliability of the basic data.

Figure 5 shows the road safety data pattern between the periods 2000 and 2017. Overall, there has been an upward trend in the increase in the number of people killed and seriously injured. Between 2000 and 2005 the numbers fell by 47% and 24% for killed and seriously injured respectively. Whilst no clear reason can be attributed to these falls, it might be related to under-reporting or other random variations. There was a steady increase in fatalities and injuries from the year 2006 which peaked in 2013. This increase might be related to the period of increasing economic activity in the country from high oil prices. However, there has been a slight reduction from 2014 and overall plateau onwards. The reduction could be related to the current economic downturn and recession following the fall in oil prices. Also, the current harmonisation of road safety data by the FRSC could be responsible for the plateauing since 2014. The new system involves a digitalised collection process, via the use of computers and other electronic gadgets at the scene of the crash. Through this method, crash data is directly inputted to the FRSC portal. Also through a new system called the National Crash Report Information System (NACRIS), road traffic crash data from different agencies such as police, the Ministry of Health (hospital data), the Vehicle Inspection Unit (VIU), and State Traffic Agencies are harmonised. However, underreporting (mostly from rural areas) and past variation in road safety data makes it hard to categorically understand the true situation of things.

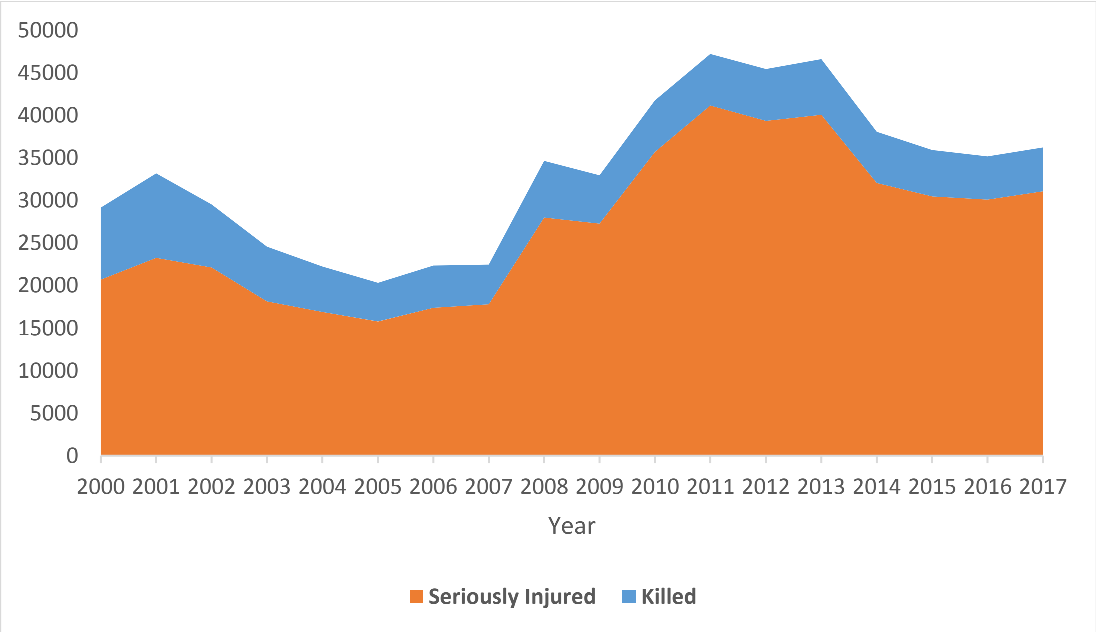

Figure 5: Killed and Seriously Injured Trend (Nigeria, 2000 - 2017)

Crashes related to deaths seem to be more reported than non-fatal ones. According to Asogwa (1992), non-fatal crashes, especially non-injury producing accidents are very much underreported in Nigeria, like in most countries. For example, he argues that cases of no litigation are missed as the police or the safety agencies are not involved. Odero et al. (1997) report that under-reporting affects the denominator applied in the calculation of fatality rates, resulting in the over-estimation of case-fatality rates. However, underreporting of deaths from road traffic crashes is not only limited to Nigeria, it is a global problem affecting many Low and High income countries (Peden et al., 2004; Harris, 1990). The same applies to single vehicle accidents where only one driver is involved. Drivers sometimes engage in mutual settlements, after excluding the road safety and police officials. There are also situations where hospital crash data are deemed unreliable, as not all crash victims go to the hospital, some end up in traditional medicine homes, and are not reported as crashes.

Another key issue in the unreliability of road traffic crash data, is the underreporting of crashes in rural areas. Most accidents in rural areas are less well reported than in urban areas due to a lack police or safety body’s presence. However, the high proportion of accidents in urban areas might be due to the fact that majority of vehicles in Nigeria are based in urban centres.

The available system for road safety investigations, and the statistical information, provide quite a limited insight into the causes of road accidents, because statistical data are unreliable and weak when it comes to analysing the causal factors of crashes. In addition, information collected by either the police or the Federal Road Safety corps are usually collected to blame the parties or for liability allocation, thereby reducing the possibility for understanding the crash contributory factors (Dayyabu, 2014).

According to Transport Research Laboratory (1990), human error is estimated to account for between 64 and 95% of all causes of traffic crashes in developing countries. Driver factors account for up to 90% of accidents in Nigeria, which includes: visual acuteness, driver fatigue, poor knowledge of road safety signs and regulation, drink/drug-driving, illiteracy, over-confidence and, above all excessive and inappropriate speeding (with other speed related factors) (Ukoji, 2014; Ogwueleka & Ogwueleka, 2012).

The vehicular factors include, un-roadworthy vehicles, tyre blowouts, poor vehicle lighting whilst the road and environmental factors include poor road designs and maintenance, traffic mix on roads, and heavy rainfall. These factors either independently or collectively cause road crashes in Nigeria (Ukoji, 2014).

1.3.3 The prevalence of speeding in Nigeria

The Federal Road Safety Corps of Nigeria has identified speed violation and inappropriate speed as a major cause of road traffic crashes in Nigeria (FRSC, 2016). Tackling the speed challenge so far has proven abortive. Current national speed limits on Nigerian roads are as follows: Urban roads: 50km/h, Rural Roads: 80km/h and Expressways: 100km/h. Ironically, only very few Nigerians drivers are aware of the speed limits before or after they begin driving. This is because getting a driver's licence is as easy as walking to a shop to buy groceries. Licence are got for a fee without any prior driving test. Most roads have no speed limit signs or either poorly signed.

Available road safety data has consistently shown speeding, and other speed related factors, to be the primary causative factor in nearly a third of road traffic crashes in Nigeria's roads (FRSC, 2013-2016). According to the FRSC, speed violation and loss of control (vehicle running off the road, with the underlying factor being excessive vehicle speeds) accounted for almost 50% of road traffic crashes in 2016 and contributed in approximately 75% of all RTCs between 2000-2016 (FRSC, 2016). In 2014, the FRSC observed average speed of various categories of vehicles on five major routes in Nigeria (FRSC, 2014b). The level of speed limit compliance can be seen in Figure 6 which shows speeding is prevalent amongst all road users, with HGV drivers' demonstrating the greatest propensity to exceed the speed limit on both single and dual carriageways.

In a more recent study examining commercial drivers' perception on the causes of road traffic accidents in Nigeria by Nwashindi (2015), speeding was found to be the major contributory factor to the risk of vehicular accidents by drivers.

Although the prevalence of speeding on Nigerian roads is not new, the national speed limit compliance data collection remains ineffective and very little evidence-based research has been carried out in this area. Almost all speed related research has been done in the advanced industrial countries. The following chapter, therefore, seeks to review the adverse impacts of speeding.

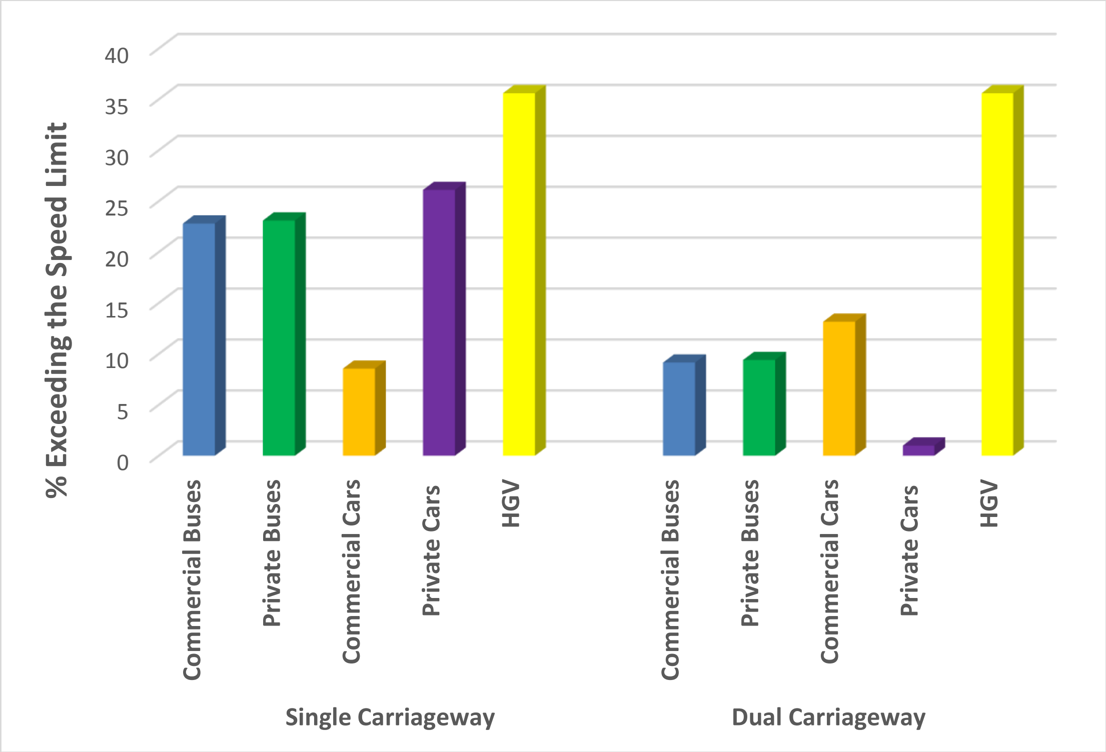

Figure 6: Percentage of vehicles exceeding speed limit on Single and Dual Carriageways by vehicle type (Source; FRSC, 2014b).

Chapter 2: Research rationale and methods

2.1 Overview

This chapter presents a brief background and motivation to the program of research addressed in this thesis. The research evaluates the efficacy of two speeding interventions: A Speed Awareness Course (SAC) and the use of an Intelligent Speed Assistance (ISA) system in the private vehicles of drivers who are employed by a fleet company with strong safety culture. With some evidence suggesting that drivers exhibit different set of attitudes and behaviours in work and private driving, this study sought to identify the psychosocial factors that influence their choice of speed in both settings. Section 2.2 describes the research background and context, together with the rationale and motivation. The aims and research questions of the programme are listed in Section 2.3, followed by the instruments used, and overview of the thesis in sections 2.4 and 2.5 respectively.

2.2 Rationale of the research

This thesis is motivated by the continuing and high occurrence of speed related crashes in Low and Middle Income Countries (LMIC), and the rationale for the thesis comes from the gaps in the research presented in the following literature review.

There continues to be a disproportionate number of road traffic crashes and fatalities (90% of the world's traffic death) in most Low and Middle Income Countries (LMIC) relative to those in High Income Countries (HIC) (WHO, 2009). Whilst road traffic crashes and fatalities in most High Income Countries are expected to reduce by 27% between 2000 and 2020, those in LMIC are expected to increase by 80%, without the introduction of new initiatives and increased efforts in combating this problem (Peden et al., 2004).

Although there exist several contributing factors to road traffic crashes, speed violations and excessive speed have been identified as one of the major cause of traffic fatalities and injuries, especially in LMIC (accounting for nearly 60% of road traffic crashes in LMIC) (WHO, 2013a). Nigeria has one of the worst road safety records in this group of LMIC, with an estimated annual 33.7 road traffic deaths occurring per 100,000 population, and speed violations and excessive speeding contributing to over 50% percent of the crashes (WHO, 2015; FRSC, 2016).

Unlike HIC where effective enforcement of safety rules, better safety culture, better transport infrastructures, technologically advanced vehicles and comprehensive research databases continue to assist with the traffic-related reduction in crashes and fatalities, very little is known about the implementation of such countermeasures in LMIC. There is also very little knowledge of citizens' perception of road safety, and the motivations for the decisions taken on the road. Specifically, despite the statistics indicating that the African region has the highest road traffic fatality rates globally, African road users are hardly ever represented (Warner et al., 2007). Finally, most LMIC lack adequate data for the assessment of the speeding problem, making it very difficult to design effective interventions.

In addition, research findings from road safety studies in HIC are not always effectively transferred to LMIC, due to differences in culture, lack of resources, unrelated traffic conditions, and a limited understanding of the factors that influence road users' safety perceptions and beliefs (Batool, 2012; Warner et al., 2007; King, 2005).

According to Lund & Rundno (2009), and Nordfjaem et al. (2011), drivers in Low and Middle income countries have a higher traffic risk perception, which may be due to their overall higher exposure to risky and unsafe traffic conditions. These drivers are therefore more likely to show willingness to risk taking. For example, Nigerian drivers are faced with roads with a desperate need of repairs, roads without speed limit signs, lack of knowledge of basic road safety tenets, vehicles in terrible conditions, and with different socio-cultural perceptions and bias. It becomes reasonable to suggest that Nigerian drivers will have less control of their speeding behaviour and will be less motivated to speed limit compliance.

The Theory of Planned Behaviour (TPB) is used in this thesis as a framework for identification and tracking of key psychological determinants of drivers' speeding intention and behaviour. It is also used in the design of a speed awareness course. There are several reasons for the adoption of the TPB framework in this research programme. Firstly, a review of the literature suggests that speed violation and excessive speeding are well-suited to explorations based within the TPB, because they are both considered as intentional and conscious acts on the part of the driver. Secondly, the TPB has been widely used in driver speeding behaviour studies, explaining the variance of drivers' intention to speeding and self-reported behaviour. However, most of these studies have only used the model for the prediction and tracking of speeding intention and behaviour with very limited studies attempting to use it as a tool for developing interventions.

This Study seeks to explore the diagnostic utility of the TPB in predicting speeding behaviour, and also testing its validity as a change model.

The thesis also explores the prospect of an Advisory Intelligent Speed Assistant (ISA) system for modifying driver behaviour and cognitions. Speed limit violations by drivers' is sometimes unintentional, thought to be due to a lack of awareness of the current speed limit, due to habit, or from poor speed calibration (Young et al., 2010). Therefore, the lack of speed limit signs on most Nigerian roads and a poor knowledge of the legal speed limits by drivers could be a contributing factor to speed violations. Thus, it was assumed that providing drivers' with continuous speed limit information, and warning them when it was exceeded could increase their Perceived Behavioural Control, and may also change their attitudes towards speed limit compliance, reducing their speeding behaviour.

The ISA system used in this research was an advisory in-car smartphone application. The choice of this device was based on the cost effectiveness of this variant of ISA. Smartphone adoption and mobile internet usage is on the upswing in Nigeria, thus an application that provides continuous speed limit information and warnings served as a cost-effective and easily accessible form of speed management tool. Given the potential safety benefits of using such a device, the thesis also explored the acceptability of the ISA system by drivers', using the Unified Theory of Acceptance and use of technology (UTAUT).

2.2.1 Work related driving

The present study is situated within work-related drivers and their driving attitudes and behaviour in this context. According to Haworth et al. (2000), work-related drivers are those who drive at least once per week for work-related purposes. Only very few organisations or companies can operate without using roads. Every day millions of vehicles; buses, vans, lorries, taxis, emergency service vehicles, couriers, police company cars, motorcycles, bicycles - are used for work purposes. Another group of work-related drivers are those who use their own personal vehicles for work purposes (e.g. for a taxi, or for volunteering). Unfortunately, those who drive these vehicles are faced and create risk for themselves and everyone else on the road whilst doing their jobs (ROSPA, 2018). Over the years there has been increased attention to work-related road safety due to the growing problem of work-related drivers being involved in road fatalities and injuries, and also the growing public and political pressure for corporate and individual accountability (Stradling, 2000; Haworth et al., 2000; Health & Safety Executive, 2004). Work related-vehicle crashes have been over-represented in fatal occupational injuries in Australia (Driscoll et al., 2001). In many countries, road traffic fatalities are one of the main contributors to work-related fatalities. For example, police accident data show that every year, almost a third of road deaths (500) in the UK involves drivers or riders who are driving for work (ROSPA, 2018). Between the period 1992 and 2016, fatal highway/transportation incidents have consistently been a contributory cause of fatal-work related event accounting for approximately one in four fatal work injuries in the United State of America (Bureau of Labor Statistics, 2017). The situation is no different in LMIC countries such as Nigeria where according to the Federal Road Safety Corps (FRSC) (2017), 60% of vehicles in road traffic crashes are work-related. A study by Lynn & Lockwood (1998) suggested that drivers who drive company vehicles are 49% more likely to be involved in crashes than the general population of drivers (private car drivers) even after adjustment for high mileage is taken into account. Lynn & Lockwood (1998) concluded that company car drivers are sometimes required to drive under time pressures imposed by tight schedules and because the cars they drive are not their own, they may be less concerned about them. This sums up the need to understand the factors contributing to work-related crashes so that appropriate countermeasures can be implemented.

A number of studies have examined factors underlying risky driving behaviour in occupational settings. An early study by Adams-Guppy & Guppy (1995), found strong time demands to seriously affect company vehicle driver's decision making particularly with speed choice and overtaking. The results from their study showed that company vehicle drivers reported frequently violating the speed limit on motorways, regarded speeding as a less important risk factor and regarded being on time for appointments as particularly desirable. Wishart et al. (2006) examined driving behaviours within an Australian organisational fleet setting using the Driver Attitude Questionnaire and reported very high levels of acceptance for speeding behaviour. Their findings were similar to previous studies by Stradling (2000) and Lajunen et al. (2003) who also found speeding to be a common aberrant driving behaviour among work-related drivers. These findings appear to suggest that this group of drivers are at risk of engaging in speed-related violations given the considerable time pressures often placed on them (Wishart et al., 2006). Other factors such as driver fatigue from working overtime and having insufficient sleep have been found to be responsible for work-related crashes and near-crashes (Fell & Black, 1996).

2.2.2 Traffic safety culture

A study by Downs et al. (1999) on why British company drivers had higher crash risk than the general population drivers suggests that the driving culture within an organisation sometimes puts business needs such as delivery quotas before safety needs. They also found that companies with strong "safety cultures" have more positive impacts on the safety concerns being addressed and were more satisfied with the outcomes of their safety measures that had been implemented. This is supported by Haworth et al. (2000) who propose that the safety culture of a company can have a significant impact upon attitudes towards driver safety and safe driving behaviour.

While there remain to be a widely-accepted definition of the concept of safety culture as many researchers describe the concept in relation to their specific area of interest. Edwards et al. (2013, p.77), proposes a synthesised definition of safety culture as "the assembly of underlying assumptions, beliefs, values and attitudes shared by members of an organisation, which interact with an organisation's structures and systems and the broader contextual setting to result in those external, readily-visible, practices that influence safety''. In the transport field, *Traffic Safety Culture* is an emerging concept and gradually gaining traction among road safety experts and scholars, as there is increased study in the role it plays in predicting and reducing risks in road transport (Nævestad & Bjørnskau, 2012).

A study commissioned by the Department of Transport in 2004 to investigate the relationship between organizational safety culture, worker–driver attitudes, and accident risk in Great Britain, concluded that there is a moderate relationship between safety culture and attitudes, and between attitudes and accidents. Other studies by Ward et al. (2010) and AAA (2007) suggest the concept may have great potential for improving traffic safety.

However, Nævestad & Bjørnskau (2012) in their study to examine how the safety culture concept can be applied to road traffic, argue that the concept cannot be applied directly to road traffic, as the high-risk organization's context in which the safety culture concept arose differs in many ways from that of road traffic. They concluded that traffic safety culture appears to be an intuitive and powerful concept with which to explain observed differences in international, regional and demographic crash risks, as well as the propensity to commit high-risk behaviours.

2.2.3 Context of the current study

The current study focuses on drivers who work in a company with a strong safety culture. The sample was drawn from Shell Petroleum Development Company (SPDC) Nigeria; an organisation that closely monitors its driver's performance and have a strong safety culture. SPDC Nigeria is an energy company involved in the exploration and production of oil and gas in Nigeria, and have very strict policies in place concerning driver safety, with penalties for careless or risky driving behaviour.

SPDC as a leading player in the petroleum industry in Nigeria, and through its “Health, Security, Safety, Environment and Social Performance” policies is committed to pursuing the goal of no harm to people, leading role in promoting best safety practice in the oil and gas industries, and promoting a safety culture in which all Shell employees share in their policies and commitment (Shell, 2018a). SPDC as part of their safety culture has put in place policies which they term “Life-Saving Rules”. These rules are meant to reinforce what employees and contractors must know and do to prevent serious injuries or fatalities. For example, employees and contractors must wear seat belts, comply with the speed limits, do not use mobile phones (even hands-free) while driving. If these rules are violated, employees face disciplinary action up to termination of employment, while contractors can be removed from the site and barred from future work with Shell (Shell, 2018b). Through initiatives such as “Goal Zero”, SPDC promotes the belief that as a company, they can operate without fatalities or significant incidents despite the often difficult conditions in which they operate. This involves improving the safety skills of staff, simplifying the company’s requirements, and rewarding successful performance. Also, through this initiative, safety and health issues are treated as a way of improving the performance of the organisation (Shell, 2018b).

With road transport being an integral part of Shell, getting road safety right is a key priority for them. Through different road safety programmes, Shell drivers are involved in a series of training in real-world driving and data analysed to help drivers improve. Journey management strategies such as In-Vehicle Monitoring Systems (IVMS) in their fleet are a requirement in all SPDC vehicles. This allows the company to analyse driver behaviour across a range of criteria such as speeding, harsh braking, and seat belt use to help ensure compliance and encourage safe driving.

Comparing Shell safety culture in relation to other fleet companies or work-related drivers in Nigeria is somewhat problematic as there is currently no evidence of any widespread fleet safety management being practiced by any organisation in Nigeria (apart from Shell and other oil multinationals) or being advocated by the government or other agencies. Any comparison will, therefore, be based on anecdotal evidence. For example, while Shell and other oil multinationals in Nigeria operate under the “rewards and control” organisation system found in most High-income countries (Mamo et al., 2014), enforcement of driving behaviour by indigenous fleets and other work-related drivers is mostly regulated by the government. According to the Federal Road Safety Corps (2010b), most fleet operators in Nigeria lack professionalism, lack institutionalised operational standards and rules, lack adequately trained fleet managers and drivers, which is compounded by lack of inspection and control by government agencies in charge. Many work-related drivers self-manage their own behaviour rather than being managed by a supervisor within an organisational context. The measurement of performance is another area where differences exist between Shell and other indigenous fleets. For example Shell evaluates driver performance under safety indices such as, speed limit compliance, and seat-belt wearing, and offers a range of awards to encourage and incentivise safe driving, including “Driver of the month” and weekly announcements of the “Perfect Driver" and “Most Improved Driver” (Shell, 2018b). Performance by other indigenous fleets is sometimes measured by set targets such as the number of trips made by the driver or delivery of a certain agreed amount of money to the fleet’s owners every day or every week (Usman & Ipinmoye, 2016). Further, Shell operates a more *proactive safety culture* which involves recognising that everything is in place and still room for improvements (Hudson, 2001), as against the *reactive safety culture* operated by most indigenous fleets in Nigeria, where attention is given to safety, but only after an accident has happened.

According to Downs et al. (1999), factors such as transportation of expensive or dangerous materials, environmental concerns, and financial benefits can make an organisation more active in driver safety, thus, can be related to the context of Shell strong safety culture.

Studies by Newnam et al. (2008) and Wills et al. (2009) have identified drivers’ perception of the safety culture in their organisation as predictors of work-related driving safety outcomes. However, anecdotal evidence during the pilot discussions with Shell Nigeria fleet managers suggests that Shell drivers exhibit different sets of attitudes and behaviours in work and private driving (non-work related driving). Telephone and face-to-face interviews with Shell Safety managers to get insights on the general road safety situation at Shell, revealed for example that, drivers’ when coming to work use their mobile phones while driving into the premises of Shell in their private vehicles. It was also revealed by the safety managers that drivers’ have been seen driving above the speed limit in their non-work settings. Both behaviours according to the Shell managers are closely monitored in work settings with a high level of compliance reported. Overall, such findings might suggest that the safety climate at work might not be transferred to non-work related settings.

There is currently very little literature available about the effects of organisational safety culture on non-work-related driving by employees. This is because it is almost impossible for companies to monitor their employees’ private driving. Also, very few organisations specifically articulate a concern for the safety of non-work-related driving by employees (Haworth et al., 2000).

Thus, this research seeks to understand the psychological processes that determine Shell Petroleum drivers intentions to speed, and their self-reported speeding behaviour when using their work and private vehicles. The choice of drivers' speeding behaviour is hinged on the over-representation of the behaviour in work-related aberrant driving behaviours (Wishart et al., 2006; Lajunen et al., 2003; and Stradling, 2000) and speeding being the biggest contributor to road crashes in Nigeria (FRSC, 2016). Although it is not within the scope of this thesis to identify why these differences occur, establishing whether they exist is important. For example, to establish whether the use of speed-reducing interventions in fleet settings can be transferred to drivers' private driving behaviours.

There continues to be limited literature investigating the determinants of driving behaviour in Nigeria. This absence in research literature represents an important limitation in current knowledge, theory and practice as evidence-based intervention is needed to address the burden of road traffic injury and death in the country.

2.3 Main aim of the research

The high level aims of the research are to:

1. Understand the psychosocial determinants of speeding behaviour by drivers in their work and private vehicles.
2. Develop and evaluate the effectiveness of speed limit compliance interventions on drivers' speed choice in their private vehicles.

This high-level aim is broken down into the following research questions.

Research questions

RQ1: What are the underlying beliefs towards speeding among Nigerian drivers?

RQ2: What are the cognitive variables which predict drivers' intention and self-reported speeding behaviour when driving their work and private vehicles?

RQ3: Will the differences in their intention to adhere to the speed limit in work and private vehicle reflect the differences in their Attitudes, Subjective Norm and Perceived Behavioural Control?

RQ4: Will the combined interventions have any effect on drivers' cognitive variables?

RQ5. Will there be any relationships between TPB variables and the objectively measured speeding behaviour?

RQ6. To what extent will the interventions affect drivers' choice of speed?

RQ7. What are the determinants of intention to use an ISA system?

RQ8. Are there differences in drivers' acceptability of the ISA system after usage?"

In order to explore these research questions, the following hypotheses were tested.

Hypotheses

H1:The standard TPB variables will significantly and positively predict intention to comply, and self-reported behaviour in drivers' work and private vehicles, such that more favourable Attitudes, Subjective Norms and Perceived Behavioural Control will predict an increased intention to comply, and higher levels of Intention, and Perceived Behavioural Control will predict Self-reported behaviour in their work and private vehicles.

H2: Drivers' will have significantly higher intentions and report higher speed limit compliance in their work vehicles, than in private vehicles, and this will be reflected in more favourable Attitudes, Subjective Norms and Perceived Behavioural Control in their work vehicles than in private vehicles.

H3: It is expected that drivers' will report significantly higher intentions and speed limit compliance after the interventions, than before the intervention, and this will be reflected in them having more favourable Attitudes, Subjective Norms and Perceived Behavioural Control after the intervention than before the intervention.

H4: It is expected that driver's TPB variables will have a significant relationship with their observed speeding behaviour.

H5: It is expected that participant's speed distribution, mean speed, speed variability, 85^{th} percentile speed and percentage of distance travelling above the speed limits will be affected/reduced by the SAC and ISA interventions compared with baseline levels across all speed zones.

H6: The standard UTAUT constructs will significantly predict intention to use the ISA system at both time intervals, such that higher Performance Expectancy, Effort Expectancy and favourable Social Influence will predict increase in Behavioural Intention.

H7: It is expected that there will be significant differences in participants' intention to use the ISA systems at Time 1 and Time 2, and this differences will be reflected in their Performance Expectancy, Effort Expectancy and Social Influence.

2.4 Research instruments approach

Study 1 was exploratory in nature, using a qualitative approach, and involved the use open-ended questions within a focus group discussion. This study was important due to the limited amount of research in this area. According to previous research using the TPB model, elicitation studies provide useful information regarding the key predictors on a behaviour, and are an important approach prior to any TPB study (Ajzen & Fishbein, 1980). Other Focus group discussions provide insights into people's overall principles, and provide greater understanding of participants' experiences and beliefs (Morgan, 1988). Therefore, a focus group method was adopted to explore the relevant concepts of speeding, by enabling personal, in-depth, descriptions by the individual participants, as well as allowing for group interaction. This qualitative study was also designed to inform the development of the questionnaires used in the quantitative phase of the program of research (Outlined in Chapter 7).

Following the focus group study, three quantitative data collection methods were used: A spot speed survey, a self-reported questionnaire, and a 1Hz GPS data logger. In the selection of the experimental route, an unobtrusive spot speed survey was conducted to provide information on the existing speed profile of the route, and involved the use of radar gun. The results from this study was more as compliment or benchmark to the experimental phase and also to minimise researcher bias[5].

Participation in Study 2 (outlined in Chapter 7) and 4 (outlined in Chapter 9) required the completion of self-report questionnaire over two time periods. The questionnaire was used to investigate the predictors of intention to speed and speeding behaviour in drivers' work and private vehicles. It was also used to monitor cognitive changes before and after the interventions. Questionnaires are widely used in driver behavioural studies (see Reason et al., 1990; Parker et al., 1992a; Newnam et al., 2004; Stead et al., 2005). The popularity is not surprising, as it allows for greater number of participants, given the ease and cost effectiveness of data collection. Furthermore, self-reported questionnaires can be a useful and efficient means of studying aberrant driving behaviour (Lajunen et al., 2004), which could be difficult or even impossible to study by using other methods (Lajunen & Summala, 2003). Despite the widespread usage of self-reporting in traffic surveys, there is the issue of social desirability bias[6] from

[5] Researcher bias is error that the researcher introduces into measurement when observers overemphasize behaviour they expect to find and fail to notice behaviour they do not expect.

[6] Social desirability bias is one of the recognized types of measurement error and occurs when a respondent provides an answer which is more socially acceptable than his / her true attitude or behaviour.

respondents. However, studies have also shown significant correlations between self-reported behaviour and observed behaviour (West et al., 1993). One of the most widely used self-report tools in road safety is the Driver Behaviour Questionnaire (DBQ), which was developed by Reason et al. (1990). The DBQ was developed to observe the distinction between errors and violations; two forms of aberration which may have different psychological origins and demand different modes of countermeasures. Reason et al. (1990) constructed a 50-item questionnaire (the DBQ). The questionnaire covered five classes of aberrant driving behaviour: slips, lapses, mistakes, unintended violations, and deliberate violation. It involved drivers self-reporting the frequency with which they committed different types of errors and violations, and identified three fairly robust factors: deliberate violations, dangerous errors, and relatively harmless lapses respectively. De Winter & Dodou (2010), through a meta-analysis, investigated the relation of errors and violations from the DBQ to accident involvement. They concluded that the construct of the DBQ (errors and violation) are significant predictors of self-reported accidents, and suggest that consistency bias always associated with self-reported surveys does not have a negative effect on the validity of the DBQ. In a study by Helman & Reed (2015) to validate the DBQ using objectively measured behaviour from a simulator, the assertion of the DBQ, and its reasonable external validity when used as a proxy for speed choice in both on-road and simulators driving was supported.

The current seeks to investigate the relationship of TPB variables of participants and their objectively measured speeding behaviour in real-life driving.

A hand-held Global Positioning System (GPS) logger was used to objectively measure participants' speed during drives on the test route. The use of the GPS as an efficient means of vehicle location determination has now been widely accepted in the transport industry as it provides useful real-time information. The GPS provides detailed tracks of the movement of individual vehicles, which allows the effects of interventions on drivers' speed choice to be investigated based either on a proportion of time travel on or of distance. Although, there exist some errors associated with GPS accuracy and precision, and is dependent on additional factors, such as satellite geometry, signal blockage, atmospheric conditions, and receiver design features/quality. The GPS data still remains a more convenient and cost-effective method of measuring speed compared with the traditional methods such as radar, tubes, mirrors etc.

Details of other instruments used in the thesis such as, an Advisory Intelligent Speed Assistance application and speed awareness course (SAC), are provided in section of

8.2.3 of Chapter 8. A schematic representation of the research design is presented in Figure 7.

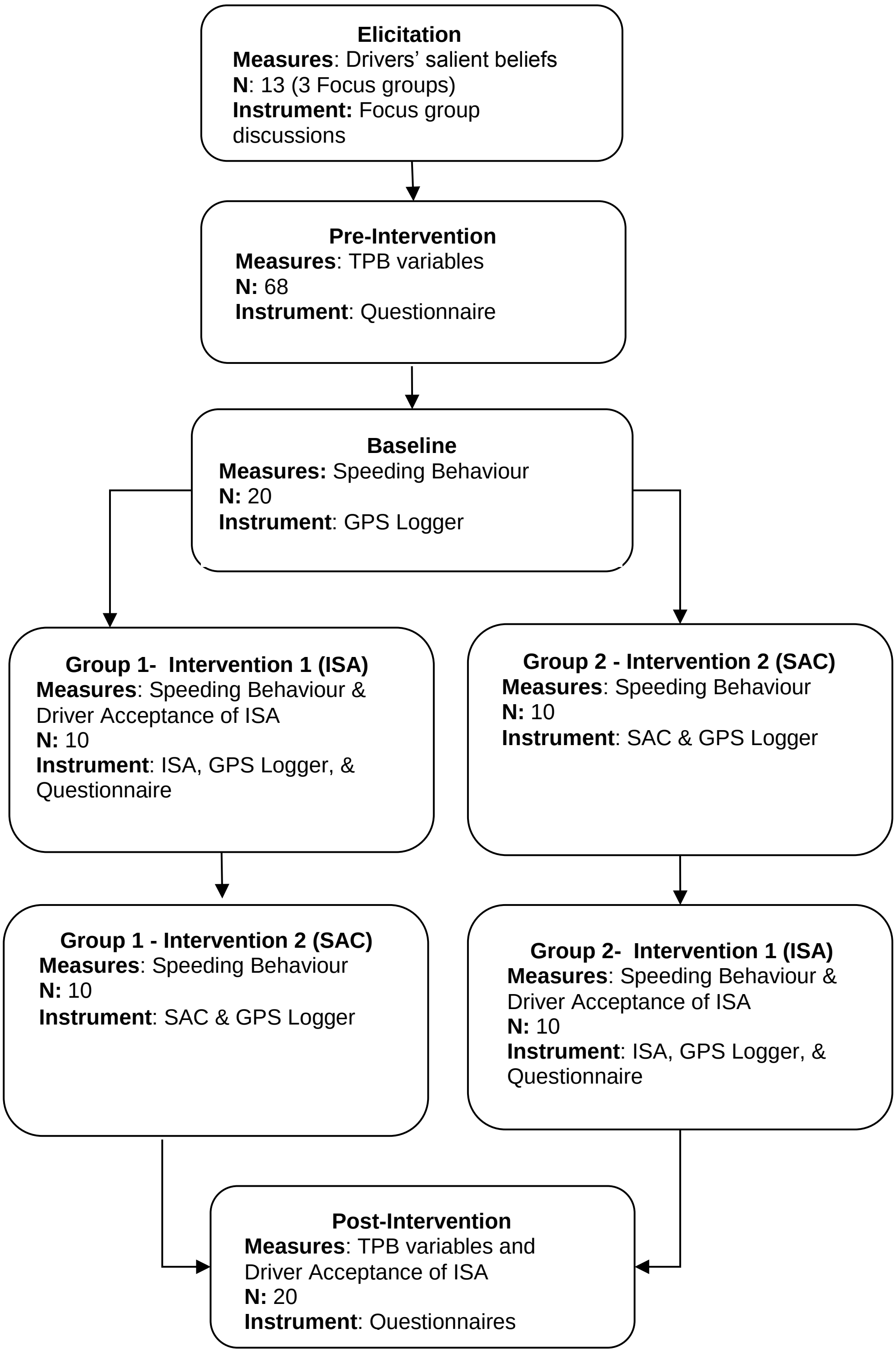

Figure 7: Thesis Research Design

2.5 Overview of the thesis

The thesis has been structured into ten chapters. Chapter 1-5 presents the pre-experimental phase of the study, while chapter 6-10 presents the individual research studies and conclusion.

Chapter One presents the current global road safety situation, the Nigerian road safety profile and the endemic speeding problem.

Chapter Two outlines the background, rationale, and context in which the study is situated. It also presents the research aims and questions.

Chapter Three gives a brief description of the relationship between speed and safety with respect to crash frequency and severity.

Chapter Four provides a review of the relevant literature on the theoretical understanding of driver behaviour and specifically examines social cognition models and their use in speeding-related studies.

Chapter Five describes the Intelligent Speed Assistance (ISA) systems and their impact on drivers' speeding behaviour, road safety and drivers' cognitions.

Chapters Six – Nine documents the four empirical studies which were undertaken within this program of research. Each of the chapters outlines the research process including the study methods (qualitative or quantitative), the results and brief discussions of the findings from each study. Specifically, Chapter Six reports the first study, a qualitative investigation of the beliefs that influence drivers' speeding behaviour and was based on the Theory of Planned Behaviour (TPB). Based on the TPB, Chapter Seven, reports the second study involving a quantitative investigation of drivers' self-reported intentions and speeding behaviour in their work and private vehicles at two time period (before and after the speeding interventions). The results compares drivers' cognitions in both settings and at both time periods, and also investigates the relationship of their cognition with observed behaviour. Chapter Eight (third study), investigate the effects of two interventions: an educational Speed Awareness course and Intelligent Speed Assistance (ISA) on drivers' choice of speed. Chapter Nine, investigates the acceptance of the ISA system used in Study 3. It focuses on the predictive utility of the Unified Theory of Acceptance and Use of Technology (UTAUT) model. This Chapters present the findings of the four empirical studies carried out. In particular, each of the chapters outlines the research design and methodology used to address the research objectives and research questions. Each chapter includes a review of the study's findings as well as a brief discussion of their implications.

Finally, Chapter Ten summarises and integrates the findings of all the studies. It provides a discussion of the significance of the research as well as making recommendations for road safety interventions.

Chapter 3: The relationship between speed and road safety

3.1 Overview

Chapter 3 of this thesis provides an overview of the link between vehicle speed and road safety vis-à-vis, crash involvement and crash severity. It also reviews and highlights the applicability of the Power Model (Nilsson, 1982) and it's efficacy in predicting safety benefits from speed changes in different cultural contexts.

3.2 Introduction

Speeding is one of the most important factors in the duality of safety and mobility, making it one of the most studied areas in road safety (Aarts & Schagen, 2006; Elvik et al., 2004; Alonso et al., 2015). It is probably the most widely spread violation of traffic rules today (Jateikiene, 2016) and according to the Organization for Economic Co-operation and Development, 40–50% of drivers' on average, drive faster than the posted speed limit (OECD & ECMT, 2006).

Speeding is found to be a contributing factor in around a third of Europe's' fatal accidents, and an aggravating factor in the severity of all road accidents (Box, 2012). Inappropriate speed and speed limit violation were identified as contributory factor for 24% of collisions, which resulted in a death in the UK in 2016 (Department for Transport, 2016) and over 50% of reported crashes in Nigeria (FRSC, 2016).

Speeding has been defined as both excessive speed (i.e. driving above the speed limit) and inappropriate speed (driving too fast for the conditions, but within the limits) (OECD & ECMT, 2006; WHO, 2008).

Over the years, significant research has shown speeding as the most prevalent contributory factor to road traffic crashes and fatalities (Elvik et al., 2004, Elvik, 2012). These studies have also demonstrated the relationship between travel speed and road traffic crash occurrence (crash involvement), and the severity of the injuries that result from them (crash consequences), (Fildes & Lee 1993; Kloeden et al., 1997; Taylor et al., 2000, Kloeden et al., 2001). Increase in speed leads to increased distance of travel during the driver's reaction time, with the stopping distance, thereby increasing the risk from driver error (WHO, 2008).

The relationship between speed and crash severity is positively correlated (i.e. increase in speed leads to a much greater percentage increase in crash severity), while that of speed and the risk of crash involvement is more complicated and not very clear because road traffic crashes can occur as a result of different elements (i.e. road/environmental, vehicular and human elements) (Feng, 2001; Aarts & Schagen, 2006; and Chorlton, 2007). Fildes & Lee (1993), made a distinction between "primary safety" (crash involvement) and "secondary safety" (crash consequences/severity). According to them the former outlines what causes crashes, and the preventive measures to be taken to avoid them, while the latter relates to protecting the individual involved in a crash. They conclude that the relationship between crash involvement and crash severity with travel speed is markedly different, and therefore, will have distinct implications for speed countermeasures.

Therefore, studying the relationship between vehicular speed and its impacts on road safety is fundamental in the quest for developing improved interventions to reduce fatalities and achieve more compliance with speed regulations.

3.3 Speed and crash involvement

The relationship between speeding and crash occurrence has not been very easy to identify, with past studies unable to confirm this unanimously. Crashes are complex events that seldom can be attributed to a single factor (Box, 2012; Fildes & Lee, 1993; Garber & Ehrhart, 2000), and there is also the limited data availability of annual average speed to represent the speeds at which crashes actually occur (Imprialou et al., 2016).

The speed-factor no doubt has a role to play in crash risks, as high speeds reduce drivers' stopping distances, which is the sum of the driver's reaction times and braking distance (Daniel, 2012). For example, when a driver travelling at high speed is suddenly faced with an obstacle, the stopping distance is the total distance he or she travels before hitting the brakes (reaction time), plus the distance travelled while the brakes slow them down (braking distance). Adequate reaction time is needed to be able to process available information to make reasonable decision and action, and this is dependent on the driver's choice of speed. This means that the possibility of a driver colliding with an obstacle in his or her path is more likely at increased speed. Figure 8 shows that longer stopping distances are required for vehicles travelling at higher speeds.

Figure 8: Typical stopping sight distances (Department for Transport, 2007).

According to Forbes (2012), at increased vehicle speed the amount of visual information that is available to the driver to process increases as the visual scene changes at a faster rate, and for the driver to manage the flow, he or she eliminates some of such information by subconsciously narrowing the visual field. Thus, at higher speed, the driver’s visual field becomes smaller as there is less time to spread gaze across the wider field of view thereby reducing the driver capacity to assess potential danger (OECD & ECMT, 2006; Box, 2012). For example, at a speed of 40km/h a driver’s visual fields span is about 100 degrees, at which potential road obstacles can be easily seen, but at 100km/h the field of vision is less than 30 degrees. (See Figure 9).

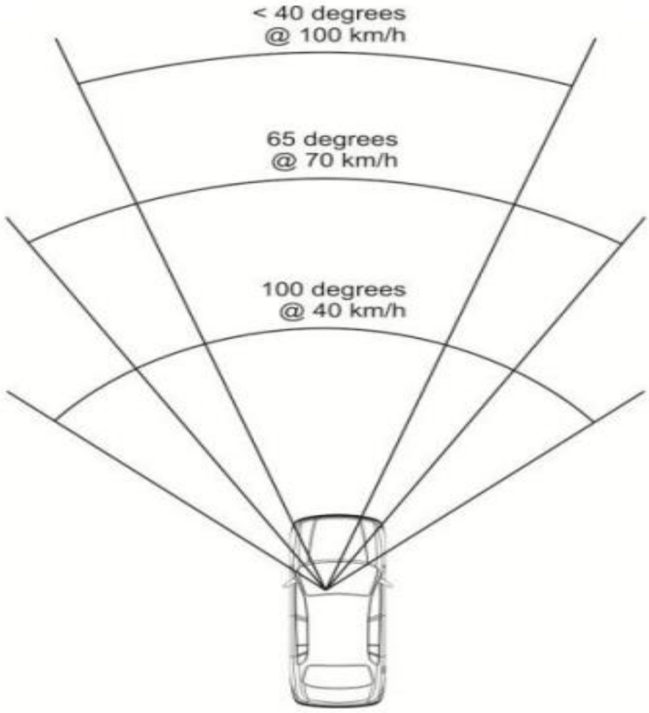

Figure 9: Speed and driver's field of vision (Source: Forbes, 2012)

Nevertheless, other factors such as the geometric features of a road, and how it is used, complexity of traffic environment, and vehicle factors can also lead to higher crash risk. The speed-crash frequency complexity can be further explained on motorways with higher speed limits having lower accidents rates in comparison with urban roads with lower speed limits. Therefore, it can be argued that the relationship between speed and crash occurrence is inverse.

In one of the earliest studies of the relationship between speed and crash involvement, Solomon (1964) and Cirillo (1968) postulated that the greater the differential in speed of a driver and his/her vehicle from the mean speed of traffic, the higher the risk of that driver being involved in a collision. These studies involved establishing pre-crash travelling speeds for vehicles involved in crashes on designated rural and interstate highways, and comparing them with measured speeds from traffic not involved in crashes. They concluded that the speed-crash relationship was U-shaped, with crash risk being elevated at both relatively low and high speeds (See Figure 10). Their argument was that the probability of a crash occurring was more related to the speed variance and not the mean travel speed. Solomon (1964) even went further to argue that relatively high speed driving is, on the average, safer than either low speed driving on main rural roads. According him, accident involvement rate is lowest at about the average speed of all traffic and highest at the very low speeds and the very high speeds.

However, there has been appraising on the validity of the results and their interpretation with particular reference to the increase in risk at the low speed zone. Example Kloeden et al. (1997, 2001), agree that crash probability at the high speed end appear to be free from bias and may be taken as indicative, at least for that place and time. Results from their studies which examined the link between absolute speed of vehicles and crash frequency, showed that the risk of a car being involved in a severe collision increased at an exponential rate for free traveling speed above the average speed of travel. According Kloeden et al. (1997), even a 5km/h faster than the average speed was found to double the risk of crash involvement (see Figure 11).

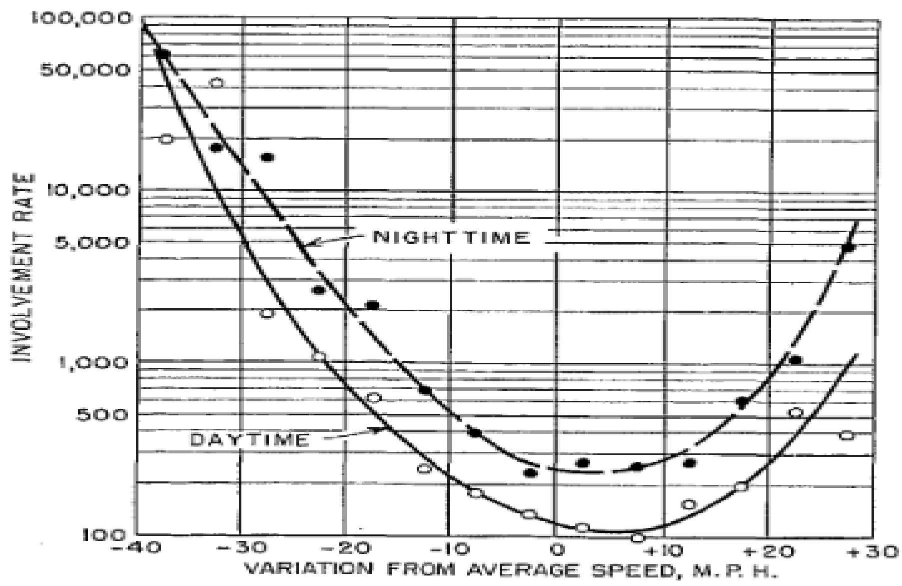

Figure 10: Crash risk by variation from average speed on study section day and night (Source: Solomon, 1964)

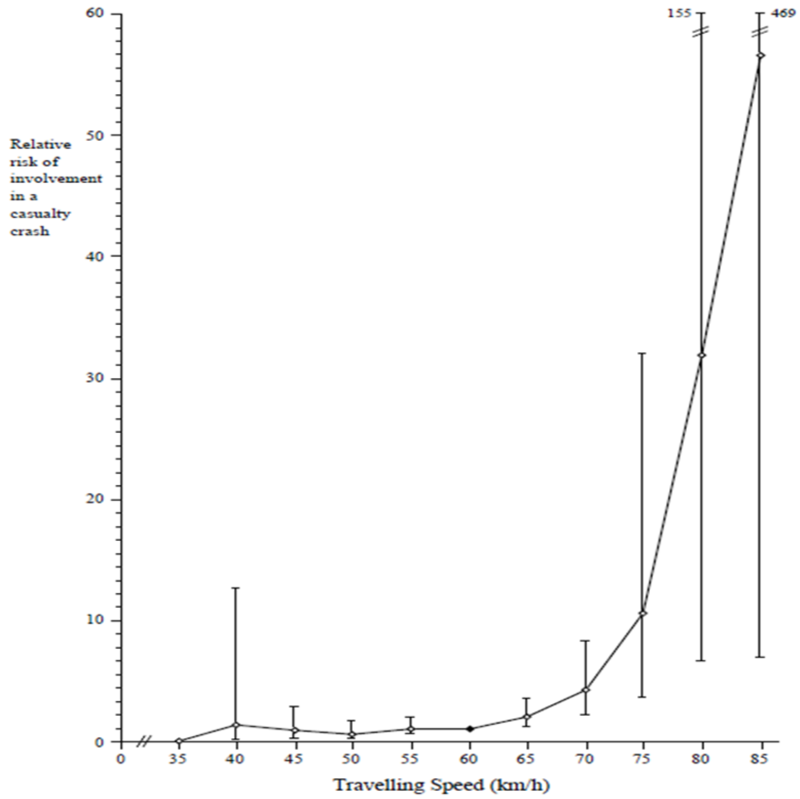

Figure 11: Travelling speed and the risk of involvement in a casualty crash (Source: Kloeden et at., 1997)

When comparing the number of reported injury crashes with speed and traffic flow on sections of urban (speed limit of 30m/h or 40m/h) and rural (50m/h or 60m/h), (Taylor et al., 2000), concluded that crash frequency rises disproportionately with increasing speed. The possibility of an accident occurring is approximately related to the square root of the average traffic speed, provided the ratio of the standard deviation to the mean remains constant. Therefore, for every 5% increase in mean speed on urban roads, there is an 11% risk of a crash occurrence, with reductions in speed expected to result in reduction in the frequency of casualty.

The literature tends to suggest that accident risk rises with increasing speed and on roads where the speed variation is greater (Solomon, 1964; Taylor et al., 2000). However only data from real-life crashes can provide information on how speed actually relates to this crash risks (Kloeden et al., 1997).

3.4 Speed and crash severity

The human body has limited capacity to cushion the effect of a collision; hence the severity of injuries is determined by the physical forces at play during crashes (Patterson et al., 2000).

The relationship between speed and injury severity at collision is very much recognised, and convincing, as the severity of the injuries sustained by the individuals involved is an increasing function of vehicle speed (Fildes & Lee, 1993). The relationship is non-linear, however, with a specified increase in vehicle speed producing a proportionately greater increase in injury severity (Kloeden et al., 1997). This relationship reflects the laws of physics, in which during collision the kinetic energy absorbed equals the square of the velocity by one half of mass; illustrating that the effect of the impact is greatly enhanced as velocity increases (WHO, 2008). For example a 10% increase in speed will result in 22% increase in kinetic energy dissipated.

Measures such as airbags and seat-belts are effective in preventing serious head injuries by offering passengers some level of protection through the absorption of part of the energy dissipated during crashes (Zador & Michael, 1993; Forbes, 2012). However, vulnerable road users like pedestrians, cyclists and motorcyclists still have a higher risk of being severely injured during crashes. The physical vulnerability of children (younger than 10 years) and the older people (adults aged 65 and above) means that their involvement in crashes is more likely to lead to serious injury or fatalities (Everison & Leeds, 2009; European Commission, 2018). This group have bones that are more brittle and their soft tissues less elastic, thus, are unable to absolve plenty of energy during crashes. Also, most pedestrians are often completely unprotected, or protection is limited for motorcyclist (IRAP, 2010). Hence, speed still remains a contributory factor in the severity of the crashes for this group.

A series of studies have been done in the past to demonstrate this relationship, but the Power Model by Nilsson. (1982; 2004) which is an adaptation from the kinetic energy formula ($Ek = 1/2mv^2$) remains the most frequently used, and well regarded, source in this context (Aarts & Schagen, 2006).

3.5 Power Model

According to the Power Model (Nilsson, 1982), the effects of changes in speed on the number of crashes and the severity of injuries can be estimated by means of a set of Power functions. The value of the exponent of this function varies with crash severity. The model postulates that the number of all injury crashes, serious injury crashes and fatal injury crashes are directly proportional to the second, third and fourth power of the relative change in mean speed respectively (Elvik et al., 2004). The Power Model takes the general form below:

$$\left(\frac{Crashes\ after}{Crashes\ before}\right)=\left(\frac{Speed\ after}{Speed\ before}\right)^{Exponent}$$

Following the Power Model, a 5% increase in mean traffic speed results in an increase of approximately 22%, and 10% for all fatal cases, and injury cases, respectively. Similarly, a 5% reduction in mean of speed also cuts down the number of cases by approximately 19% for fatal cases, and 10% for all injury cases. The consequences of increased speed are far more serious and dramatic for vulnerable road users. For example, if a vehicle collides with a pedestrian at a speed of 30km/h, the chance of the person dying is 5 %. At a speed of 50km/h, it is 45%, and at 65km/h this goes up to 85% (ETSC, 2008).

In 2004, Nilsson refined the model, developing six equations: for fatalities, severe injuries (fatal and serious injuries), and for all injuries. There are equations also for fatal crashes, crashes involving fatal and serious injury, and for all injury crashes. See Figure 12 for the safety relationship of the Power Model.

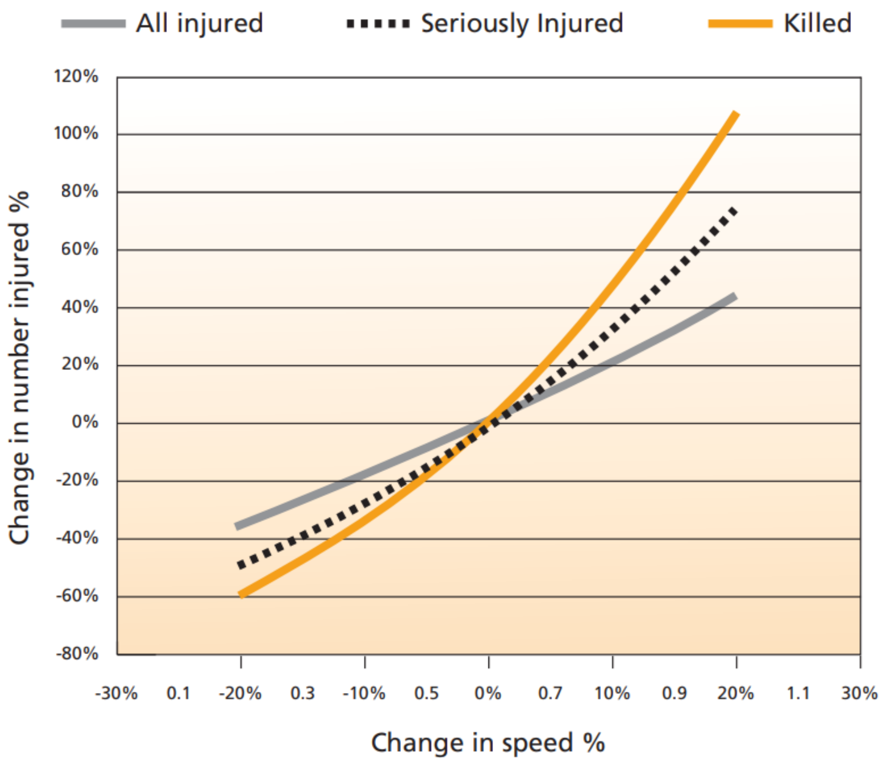

Figure 12: Illustration of the Power model relationship between change in speed and change in the number killed and seriously injured (Source Nilsson, 2004)

Results from the meta-analysis evaluation of the Power Model relationship with speed and crashes by Elvik et al. (2004) shows clear support for the model, with a strong causal relationship between changes in traffic speed and changes in road safety. However, some inconsistencies were pointed out with the exponents, with overlap between the categories of crashes. For example, fatal accidents were represented by the exponents 4 when considered exclusively. The exponent for accidents involving fatal or serious injury is 3. The exponent for all injury accidents, including fatal accidents, is 2. Elvik et al. (2004) argue that the exponents cannot all be the same for the same category of crashes, thus, they sought to reformulate the model.

In a revised version, Elvik (2009) argues that the effect of speed on crashes is dependent on the initial speed, and is moderated by the traffic environment. A proposal for lower exponential values for the Power Model, with much lower values on urban and residential roads, than rural roads and motorways was made. Thus, suggesting that the effect of speed is diminishing, although it remains a powerful risk factor in crashes and injury severity. The most likely explanation for the slight decrease over time comes from improvements in vehicle safety (seatbelts, crash areas and airbags), more "forgiving roads", lesser number of vulnerable road users (pedestrianisation), and more safety conscious people. See Table 1 for the modified version of the exponents.

Table 1: Modified exponents for the Power model (Source: Elvik, 2009)

	Rural roads/Freeway		**Urban/Residential**		**All Roads**	
Accident or Injury severity	**Best Estimate of Exponent**	**95% confidence Interval**	**Best Estimate of Exponent**	**95% confidence Interval**	**Best Estimate of Exponent**	**95% confidence Interval**
Fatal accidents	4.1	(2.9,5.3)	2.6	(0.3, 4.9)	3.5	(2.4,4.6)
Fatalities	4.6	(4.0-5.2)	3.0	(-0.5,6.5)	4.3	(3.7, 4.9)
Serious injury accidents	2.6	(-2.7,7.9)	1.5	(0.9,2.1)	2.0	(1.4, 2.6)
Seriously injured road users	3.5	(0.5-5.5)	2.0	(0.8-3.2)	3.0	(2.0, 4.0)
Slight injury accidents	1.1	(0.0.- 2.2)	1.0	(0.6, 1.4)	1.0	(0.7, 1.3)
Slightly injury road user	1.4	(0.5, 2.3)	1.1	(0.9, 1.3)	1.3	(1.1,1.5)
Injury accidents(All)	1.6	(0.9,2.3)	1.2	(0.7,1.7)	1.5	(1.2,1.8)
Injured road users (All)	2.2	(1.8.2.6)	1.4	(0.4, 2.4)	2.0	(1.6,2.4)
Property-damage-only accidents	1.5	(0.1,2.9)	0.8	(0.1,1.5)	1.0	(0.5, 1.5)

A re-parameterisation of the Power Model by Elvik (2013), established that the relationship between speed change and injury crashes is best fitted by exponential models, as it predicts much larger effects of changes in speed at high levels of initial speeds than the original Power Model. However, Elvik (2013) still maintains that the Power Model best fits fatal crashes, with only very slight differences between the power and exponential functions.

The efficacy of the Power Model in predicting changes in traffic speed remains realistic, as it has received clear support from past research (Carsten & Fowkes, 2000; Regan et al., 2006a; Ghadiri et al., 2013). However, it is worthy to note that the Power Model was calibrated for high income countries, which have higher quality of roads and infrastructure, better traffic laws, and vehicles that are more energy-absorbing. Hence its application to low and middle income countries might differ. LMIC are known to have for higher burdens of road traffic crashes and fatalities, lower seat belt wearing, and less protective vehicles, lack of emergency services, lack of road barriers, and poor facilities for vulnerable road users, thus, there is likelihood that the exponents might be higher in such countries. For example, a crash at a given speed may be more likely to result in serious injuries or fatalities in Nigeria, than in the UK. Therefore, the Power Model will predict that a crash at a given speed is more likely to result in severe outcomes in developing nations as opposed to developed nations.

Generally speaking, at present, the direct implementation of speed control measures proven to be effective in industrialised nations does not produce the same safety improvement in developing countries with several factors accounting for this (Afukaar, 2003). For example, most developing nations lack enforcement infrastructure, and have no clear road safety strategies. Vehicles used in these countries are relatively old or second-hand, often lacking modern safety gadgets like seat-belts and airbags. According to Tingvall & Haworth (1999), passengers wearing seat-belts and using well designed vehicles have more protection for travelling speeds up to a maximum of 70km/h in frontal impacts, and 50km/h in most side impacts.

Road traffic injuries in developing nations mostly affect the vulnerable road users (pedestrians and cyclist) and passengers, contributing to around 90% of deaths. This is in contrast to industrialized countries, where drivers are mostly victims of road traffic injuries (Nantulya & Reich, 2002). According to Carsten (2014), the quality of roads affects the relationship between traffic speed, and injury crashes. Lower quality roads have greater impacts from changes in traffic speed than better quality roads. Most high-income nations have over the years seen improvement in their road and traffic infrastructures, and regulations, which has resulted in lower exponents in the Power Model. It can therefore be hypothesised that the exponents will be smaller in LMIC. Therefore, you would expect that any given change in speed in developing nations will have lower impacts on road safety estimation than developed nations.

3.6 Chapter summary

The relationship between vehicle speed and road safety has continuously been shown in past studies. Crash frequency is shown to rise with increased speed and on roads with high speed variability. Furthermore, the severity of injuries in a crash is likely to be greater at higher speeds. Although, the exact link between speed and crash rate and injury severity is hard to be quantified, given the moderating effect of numerous road, traffic, and vehicle characteristics remains largely unknown. However, there is a common agreement that speed contributes directly or indirectly to crash rates and increases the seriousness of injury or death. The next chapter seeks to examine the psychosocial factors and models that predict driver behaviour.

Chapter 4: A theoretical understanding of driver behaviour

4.1 Overview

This Chapter examines social cognition models that have been used to investigate driver behaviour. It begins with an examination of the Attitude-Behaviour relationship and then proceeds with the review of some widely used theories in road safety, the Health Belief Model, Implementation Intention, Theory of Planned Behaviour and the Unified Theory of Acceptance and Use of Technology.

4.2 Introduction

The driving task is a very demanding one, with many determinants to the task level, ranging from the remote ones (choice of vehicle, choice of route) to the immediate ones (actions of other road users). However, a key determinant to the level of difficulty in the driving task, and which is under the volition of the driver is the speed at which the driver decides to move (Fuller et al., 2006).

Research over the years has shown excessive and inappropriate speed to be one of the most important factors in road traffic crashes and their severity. However, despite extensive research linking speeding to crashes and severity, the prevalence of speeding remains high in many countries, and the behaviour continues to be pervasive and a social norm among drivers. (Fleiter & Watson, 2006; Hjalmdahl & Varhelyi, 2004). However, in some countries such as the UK, speed limit violations is reducing as a result of effective countermeasures put in place. These include; education (Department for Transport ‘Think Country Roads’ campaigns), training for offending drivers (National Speed Awareness Course), reduced speed limit zones (20mph zones), enforcement (speed cameras and speed warning systems), and engineering (traffic calming such as speed humps and chicanes).

Government and policy makers all over the world have taken measures and sometimes a hard stance on reducing this risk, through legislative and physical countermeasures, such as setting of speed limits, enforcement (speed cameras, fines for violation, point deductions etc.), and traffic calming infrastructures (chicanes, speed bumps, roundabouts etc.). These interventions have no doubt been successful in improving road safety (for review see Comte, 2001). However these interventions only bring changes by “peripheral enforcement”, and are not thought to affect drivers’ inherent motivations to speeding, and are often limited to time and space (Paris & Broucke, 2008). Bunn et al. (2010) reviewed area-wide traffic calming interventions such as road humps, speed cushions, reduced speed limits zones of 30km/h, mini- roundabouts, speed cameras, and increased fines, and found that the controlled before-after design may have the potential to reduce road traffic deaths and injuries, with the possibility of reducing pedestrian injuries. However, they concluded that there is still need to rigorously evaluate their effectiveness, particularly in middle and lower-income countries.

Driver's speed choice may either be intentionally or unintentionally. However, other factors such as characteristics of the driver which are related to human perceptual skills and limitations, characteristics of the road and the road environment, and characteristics of the vehicle also influence this behaviour (Aberg, 2001). The driver-factor has been known to be a major contributor to crashes, hence, knowledge and understanding of factors that motivate speeding, and modification of driver speeding behaviour, will offer an opportunity for crash and injury reduction (Aberg, 2001; Evans, 1996; Haglung & Aberg, 2000).

Studies on the influence of demographic variables on drivers' speeding behaviour are well documented (Parker et al., 1995a; Stradling et al., 2003; Stradling et al., 2004). These studies have found male drivers, younger drivers, and high mileage drivers to be high speeders compared with female, older and low mileage drivers and as such this have been used to develop countermeasures. However, in developing more effective interventions this information on driver demographics and characteristics are limited (Elliot et al., 2004). For example knowing that younger drivers drive faster is not enough, but what variables explain why younger drivers drive faster. Hence, there is a need to investigate, understand, be able to predict and modify the underlying factors and motivations responsible for the speeding behaviour of this group of drivers in the hope of proffering change and modification of such behaviours.

4.2.1 The relationship between Attitude and Behaviour

In the field of road transport safety, Attitudes and beliefs have been discussed extensively in a number of road user behaviours, such as, use of safety belts (Tavafian et al., 2011a), drink driving, overtaking, lane changing (Parker et al., 1992a; 1992b; 1995b) and speeding (Parker et al., 1995b; Pelsmacker & Janssens, 2007). Negative attitudes have been frequently attributed as a cause of bad behaviour in traffic, and it is stated that a likely change in attitude will result in great improvement in road user behaviour and road safety (Musselwhite et al., 2010). This relationship between attitude change and improved safety suggests that there is a causal relationship between attitude and behaviour, and that it is possible to influence the attitudes of road users (Aberg, 2003).

However, drivers' attitude and beliefs to speeding behaviour have always been a paradox. There is always a mismatch between their beliefs and actual performance of the behaviour (Fleiter & Barry, 2006). For example anecdotal evidence suggest that most drivers' subscribe to the belief that speeding is dangerous and wrong, yet regularly drive at excessive and inappropriate speeds.

The attitude-behaviour relationship, is subject of much debate in the literature. There have been a series of arguments on the precedence of each; with some arguing that attitudes predict behaviour (Fischbein & Ajzen, 1975; Ajzen & Fishbein, 1980; Kraus, 1995; Iversen & Rundmo, 2004), while others describe attitudes as being epiphenomenon (influenced by behaviour but not having an influence on behaviour) (Kelman 1974). Lapiere (1934), in an empirical study of the attitude-behaviour relationship, concluded that attitude could easily be quantitatively measured, but provided little or irrelevant prediction of behaviour.

Fischbein & Ajzen (1975), described attitude as a learned predisposition to respond in a consistently favourable, or unfavourable, manner with respect to a given object. Their views were later shared by Eagly & Chaiken (1993) who described attitude as a "*psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour ordinarily expressed in cognitive, affective and behavioural responses*". This later definition has been widely used by social psychologists (cited by Aberg, 2001; Aberg, 2003; Iversen & Rundmo, 2004; Musselwhite et al., 2010).

According to Rosenberg & Hovland (1960), people's attitudes are hinged on three major classes of responses; cognition, affect and behaviour, which are referred to as the *three components of attitudes* (Nordlund, 2009). Cognitive responses refer to thoughts and beliefs people have about the object. Affective responses refer to feelings, emotions and moods that people experience in relation to the object, whilst behavioural responses are people's intentions to perform or performance of the object (Eagly & Chaiken, 1993).

In this context, driver speeding behaviour is the object and entity, and it is in some way guided, shaped, influenced, directed and predicted by their attitude (Iversen & Rundmo, 2004; Kraus, 1995). Thus, drivers' attitudes towards speeding are influenced by their thoughts and beliefs, their emotions and feelings when speeding and their intention to speed or performance of the behaviour.

The speeding behaviour of drivers' is a very complex challenge of which understanding the determinants or predictors of the behaviour could lead to the development of effective and robust intervention which could serve as countermeasures in the hope of reducing speeding among drivers'.

Series of studies have hypothesised attitudes towards speeding by drivers' to be a key determinant of the speeding behaviour (Hatfield et al., 2008; Chorlton, 2007), but the extent of which speeding behaviour is predicted by drivers' attitudes and beliefs towards speeding and how to change this behaviour has been of great contention in many studies. Aberg (2003), in his study of the role of attitude in transportation studies, concluded that attitude is only one of several factors that affect behaviour, and that this effect varies over behaviours and situations. Therefore predicting speeding behaviour is complex, and has to be based on several factors.

Many researchers have used psychological models to explain the attitude-behaviour relationships, with the hope of motivating change. These theories and models have their strengths and limitations and none has complete scientific coverage of the scope of factors involved in the performance of these behaviours. Though no single theory or model has gained universal acceptance among safety research field, they nonetheless have shaped our understanding of attitude-behaviour relationship.

Some of such models and concepts include: Health Belief Model, Implementation Intention Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the Theory of Planned Behaviour (Ajzen & Fishbein, 1980), and more recently the Unified Theory of Acceptance and Use of technology.

4.3 Health Belief Model

The Health Belief Model (HBM) is a widely used conceptual framework developed in the 1950s for the prediction of health-promoting behaviours (Rosenstock, 1974). The original model proposes four dimensions in the prediction of behaviour:

- ***Perceived Susceptibility*** (a person's subjective perception about the likelihood of contracting a condition),
- ***Perceived Severity*** (a person's feeling about seriousness and consequences of contracting a condition),

- ***Perceived Benefits*** (a person's perception of the extent to which there will be benefits as a result of engaging in an alternative safety behaviour) and
- ***Perceived Barriers*** (a person's perception of likely impediments to undertaking the alternative safety behaviour) (Rosenstock, 1974; Janz & Becker, 1984).

The combination of the former two dimensions is referred to as Threat Perception component and the latter two dimensions termed Behavioural Evaluation component.

Additional dimensions of: ***Self-Efficacy*** (a person's belief in their ability to perform a health protective behaviour) and *Cues to action* (factors that trigger or serves as reminders to a person on their way to performing an alternative safety behaviour) were added to later versions of the model (Sheeran & Abraham, 1996).

The HBM has been used in the prediction of various driving behaviours such as cyclist and motorbike helmet usage (Lajunen & Rasanen, 2004; Aghamolaei et al., 2011), seat belt usage (Tavafian et al., 2011a; Ali et al., 2011) and risky driving behaviour (Morowatisharifabad, 2009). The HBM has shown relative success in providing insights into the determinants of driving behaviour, but there have been some criticisms of the model. For example, Armitage & Conner (2000), argue that the model has poor construct definition, a lack of combinatorial rules, and weakness in the predictive validity of HBM core constructs. Champion & Skinner (2008) suggest the HBM is limited, in that it is a cognitively based model that does not consider the emotional component of behaviour. According to Taylor et al. (2006), there are factors other than health beliefs may influence health behaviour (example social norms, cultural factors and past experiences). Thus, the HBM may be used to derive information that may then prompt behavioural change intervention designs, but not for decision making on the intervention structure.

4.4 Implementation Intention

According to the Nobel Laureate Anatole France "*It is human nature to think wisely and act foolishly"*. In the context of speeding, although most people know that excessive speeding or non-compliance with speed limits is dangerous and sometimes they even have positive attitudes and intention towards speed limit compliance, yet they still go ahead and speed.

Although, past research has provided evidence that there is a relationship between driver's motivation to speed limit compliance (i.e. their intention) and actual performance of the behaviour (see Parker et al., 1992a; Conner et al., 2007; Letirand & Delhomme, 2005), there still exist an intention-behaviour gap, as not all driver's intentions are translated into action. For many, research shows that there is a 'gap' between what they intend to do, and what they actually do (Elliot & Armitage, 2009a).

In a conceptual and empirical review of the Intention-Behaviour relationship, by Sheeran (2002), he postulates that the gap is caused by two groups: "Inclined Abstainers" (example drivers' with positive intention but who fail to act) and "Disinclined Actors" (example drivers' who comply with speed limits despite their negative intention to do so). Sheeran concluded that the lack of consistency between motivation to perform a behaviour, and behaviour itself, is mainly due to Inclined Abstainers rather than the Disinclined Actors). Elliot & Armitage (2006) reported that Inclined Abstainers represent 72% of all drivers' who did not translate their intentions to the target behaviour and over 50% of all drivers', who did not regularly comply with speed limits.

Elliot et al. (2003), argue that the reason why positive intention of most drivers' to speed limit compliance is not always translated to the target behaviour, is because speeding is habitual, and habits tends to interfere with the process of translating motivation to action. Regardless of whether a person intends, to drive in a safe manner or does not intend to, habitual processes (automatic or mindless processes developed out of frequent experience with the environment and occur without fore thoughts or conscious information processing) tend to supersede cognitive processing (systematic appraisal of information before acting) (Musselwhite et al., 2010).

Traditional road safety educational interventions geared at changing driver speeding behaviours have mostly been based to raise awareness, provide advice, promote positive attitudes, and motivate intentions. Elliot & Armitage (2006), argue that these campaigns are not always able to translate the good intentions generated into action, as a result of their limited impacts on the behaviour. These campaigns mostly try to motivate drivers' to speed limit compliance, without subsequently helping them develop strategies and plans to perform the behaviour. Hence, a reason why speeding still remains prevalent on roads.

According to Brewster et al. (2015), and Elliot & Armitage (2009a), interventions with social cognitive models such as the Theory of Reasoned Action (TRA) and its extension: The Theory of Planned Behaviour (TPB) which is arguably the most widely researched driver cognitive model, might be limited in converting drivers' motivation into action. According to them the TPB is primarily concerned with formation of intentions, as the key determinants of behaviour. They argue that, most drivers' are **largely aware**

of the risk of their behaviours, know **at least some ways in which they could change their behaviours** and are **on average motivated to change**. Therefore, attempts to motivate drivers' to comply with speed limits, or avoid excessive speeding, might become ineffective. Thus, developing interventions that help in the implementation of drivers' intention into action becomes imperative.

It is on this framework that the concept of "*Implementation Intention"* was developed by Gollwitzer (1993). Implementation Intentions are volitional (IF-THEN) strategies that help individuals translate their motivation (goal intention) into action (behaviour) (see Sheeran, 2002; Gollwitzer, 1993). Implementation Intentions require that people specify when, where and how the intended action will be carried out. People are more likely to perform an action at the time, location and how they have previously specified in their Implementation Intention (Milne et al., 2002; Orbell et al., 1997; Sheeran & Orbell, 1999).

According to the action-phase model postulated by Heckhausen & Gollwitzer, (1987); Heckhausen (1991); and Heckhausen & Heckhausen (2008), there are two important transitions that lead to the successful performance of an action. The first is a Motivational Phase which Milne et al. (2002) describes as the stage where the individual weighs up the costs and benefits of performing the behaviour and which involves formation of intentions. The second is the Volitional Phase or Post-Intentional Stage in which people develop strategies that ensure their motivation is translated into action.

In the context of speeding, a driver who has positive intention towards speed limit compliance will specify a situation to perform the action. Example "*if I am tempted to speed when late for work….* and the how, "*Then, rather than speed, I will try to relax and drive in a more careful/ considerate/responsible manner*…"

There are therefore two critical components to an Implementation Intention: the identification of a response that will lead to goal attainment; and the identification of a suitable situation in which to initiate that response (Elliot & Armitage, 2009a).The process of implementing the individual motivations involves him or her relating the situational cues to the behaviour-directed response, through a conscious act of will (Sheeran et al., 2005) According to Sheeran et al. (2005), Webb & Sheeran (2004), and Gollwitzer (1993), Implementation Intentions increase the chances of a behaviour being performed because, they ensure that cues in the environment will trigger the behaviour in the future. They increase the speed of responding, increase information processing efficiency and operate within conscious awareness. With Implementation

Intention, the opportunity for action is not missed, even if it presents itself for only a fleeting moment (Milne et al., 2002).

Brewster et al. (2015), Elliot & Armitage (2009a), and Sheeran et al. (2005) have all likened the effect of Implementation Intention to that of Habit, with differences only in their formation. According to them, both have a link in memory between the behaviour and certain environmental cues. In Habits the relationship between the situation and the response that produces the behaviour is developed through past behavioural experience whilst in Implementation Intention the relationship is developed through conscious thoughts and occur with the individual being aware of their goal intentions (Adriaanse et al., 2011; Brewster et al., 2015;).

Their similarities have led researchers to propose that Implementation Intentions are capable of breaking the link between past behaviour (i.e. Habits) and future behaviour. Implementation Intentions are capable of mimicking habits via interference of habitual responses (Sheeran & Orbell 1999). According to Adriaanse et al. (2011), when Implementation Intentions are stipulated, they present alternate responses to habitual response which then become equally accessible to the individual and both competing for performance, but with a strong goal intention the alternate responses are activated and with subsequent repetition of the new alternative a mental link is created between the new strategy and the critical situation leading to automatic performance. If drivers' with positive intention to comply with speed limits are able to state when they are likely to violate speed limits and the strategies they will use to comply, the stipulated intentions will be automatically translated to behavioural performance whenever the situation arises.

Implementation Intention has been used in a wide variation of behavioural studies ranging from health, environment, education, consumer and has shown medium size effects in behaviour changes, with individuals who form Implementation Intentions more likely to perform the behaviour compared with controls (for a review see Gollwitzer & Sheeran, 2006).

4.4.1 Application of the Implementation Intention on driver behaviour

To date, only two studies have tested the efficacy of Implementation Intention in the context of driving. The first was by Elliot and Armitage (2006) in which they investigated the efficacy of Implementation Intention on speed limit compliance. They also investigated the interaction between goal intention and Implementation Intention and examined content effectiveness (whether the number of cues and strategies increased driver's speed limit compliance). The results showed that the experimental group who specified Implementation Intentions subsequently increased their compliance with 30mph speed limits more than the control group with observed effects sizes approaching a medium magnitude (d=0.43)[7]. However, their results did not show any increase in drivers' motivation to speed limit compliance, supporting the contention that people may not be motivated to perform behaviour before volitional strategies such as Implementation Intention have effects on their action (Heckhausen & Gollwitzer, 1987). The study did not find any statistical significance with the number of cues and strategies and speed limit compliance.

In a more recent study by Brewster et al. (2015), the researchers investigated the impact of Implementation Intention on drivers' speeding behaviour as in the Elliot and Armitage (2006) study. However they used a more selective sample of inclined abstainers (drivers' with positive intention to speed limit compliance who did not subsequently perform the target behaviour), and an active control group (i.e. the control group had road safety information about speeding and safe driving tips). The intervention group were provided with a volitional help sheet. The results showed a significant increase in speed limit compliance by drivers' who specified Implementation Intentions with an estimated effect size of d=0.39 as compared with the control group despite both groups reporting the same levels of motivation to speed limit compliance and speeding behaviour.

In the context of speeding behaviour, Implementation Intention has the possibility of offering a cheap and effective strategy for translating driver's positive attitudes and motivations towards speed limit compliance to their target behaviour.

Studies with Implementation Intention have infrequently used stringent, objective measures of behaviour. Therefore there may be a need for further studies to objectively measure the drivers' speeding behaviour either via simulators studies or instrumented vehicles to minimise the potential vulnerability of self-reported measures of speeding as done in the past two studies (see Elliot & Armitage, 2006; Brewster et al., 2015). Although, there continue to be questions on the similarities of driving simulators data to behaviour in the real world. Rudin-Brown et al. (2009), argue that whilst it is not always possible for all elements of the simulator to be similar to real-world vehicles, the choice

[7] Effect size: is a simple way of quantifying the difference between two groups. It is used to see how much an independent variable has affected the dependent variable. E.g. 43% of the increase in speed limit compliance was accounted by the implementation Intentions specified by the driver.

of the use of a simulator should be based on the set cues that are important to a specific task. Knapper et al. (2015) compared a fixed-base driving simulator to real road regarding distracted driving speed, their results suggest evidence for relative validity with regards to studying effects on speed for distracted driving.

There is also concern over the long-term effects of the Implementation Intention, as previous studies in the context of driver behaviour have used only one-month post intervention.

Another area for possible research is testing the efficacy of specific situation cues and goal-strategies that are most effective for behavioural change (Brewster et al., 2015). Past studies have so far shown that the impact of specifying Implementation Intention is proportionate with increased driver motivation to speed limit compliance; Implementation Intentions therefore cannot serve as a framework for intervention aimed at changing drivers' intention designed (Chorlton, 2007); instead it should be used in combination with a motivational intervention designed to increase goal intention (Fylan et al., 2006), as forming Implementation Intention will not on its own influence drivers' speeding behaviour. It therefore has to be preceded by motivation of the drivers'.

4.5 Theory of Planned Behaviour

The efficacy of the Theory of Planned Behaviour (TPB) and its earlier version the Theory of Reasoned Action (TRA) in predicting a wide range health- behavioural Intentions and actual Behaviour is well documented (For review see Conner & Armitage, 1998; Armitage & Conner, 2001). The TPB has also been widely used within the transport safety area to understand and predict the individual factors of various driving behaviours with relative degree of success (Conner & Armitage, 1998). The models also serve as useful tool for identifying intervention targets, because it proposes a number of potentially modifiable determinants of driver behaviour (Elliot & Thompson, 2010). It usefulness in such behaviours include; Drink driving, close following, dangerous overtaking, (Parker et al., 1992a; Parker et al., 1992b), lane changing (Parker et al., 1995b), seat belt wearing (Ali et al., 2011) cycle helmet usage (Quine et al., 1998) and speeding (Parker et al., 1992a; Parker et al., 1992b; Elliot & Thomson, 2010; Pelsmacker & Janssens, 2007; Paris & Broucke, 2008; Newnam et al., 2004).

The Theory of Reasoned Action (TRA) proposes a model which can measure how human actions are guided. It predicts the occurrence of a particular behaviour, provided that behaviour is intentional. It postulates that Attitudes and Subjective Norm (SN) determines Intentions and that Intention determines Behaviour (Fishbein & Ajzen, 1975). Due to its limitation in dealing with behaviours over which people have incomplete volitional control (Warner & Aberg, 2006), (that is, the theory only applied to behaviour that is consciously thought out beforehand, leaving out habitual actions and irrational decision), an extension, the Theory of Planned Behaviour (TPB) was postulated to incorporate Perceived Behavioural Control (PBC) as a third predictor of Intention and independent of Attitudes and Subjective Norm (Ajzen & Fishbein, 1980; Ajzen, 1991), to address behaviours that occur without volitional control.

According to the TPB, volitional behaviour is to a large extent determined by the Intention to perform that behaviour and the Perceived Behavioural Control. *Intention* is the summary of the motivation or willingness to perform the behaviour and *Perceived Behavioural Control* is people's perception of their ability to perform the behaviour. Intentions are in turn determined independently by the cognitive variables: *Attitudes* (which is the degree to which a person has a positive or negative evaluation to performing the behaviour) *Subjective Norm* (the perceived social pressure by significant others to perform or not perform the behaviour) and Perceived Behavioural Control. (Ajzen, 1991; Elliot et al., 2004; Paris & Broucke, 2008; Warner & Aberg, 2006; Ketphat et al., 2013; Pelsmacker & Janssens, 2007). Figure 13 below illustrates the TPB framework. In the rest of this chapter, the TPB variables of Attitude, Subjective Norm and PBC will be referred to as standard TPB constructs.

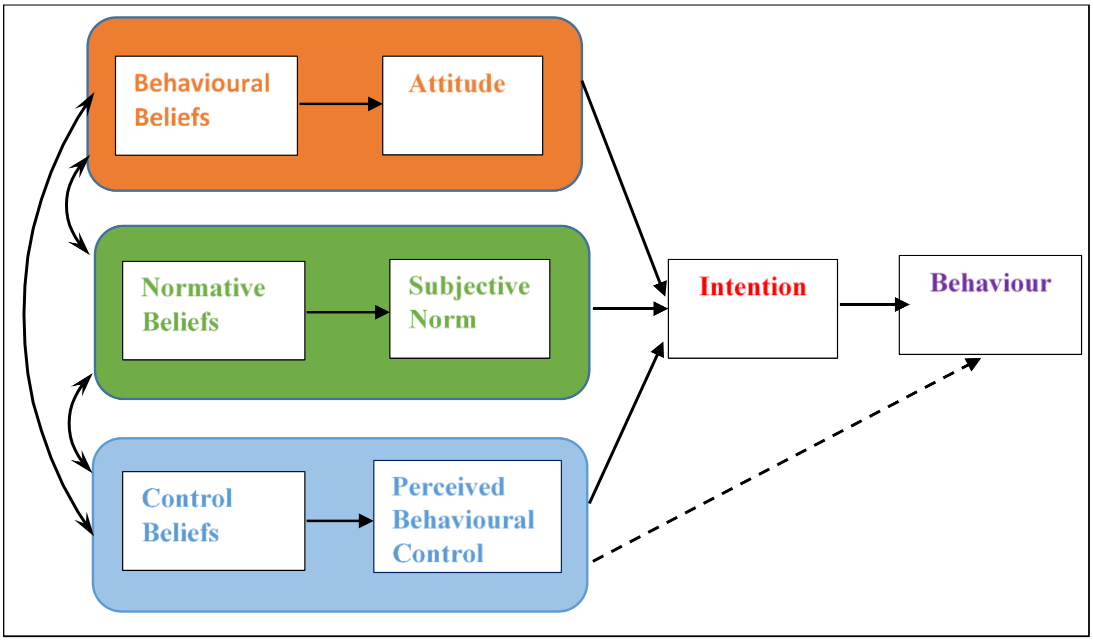

Figure 13: Theory of Planned Behaviour (Source: Ajzen, 1991)

Put simply, the TPB proposes that behaviour is a function of salient beliefs relevant to that behaviour, and these salient beliefs are the prevailing determinants of a person's intention and actions. Thus, to determine behaviour, the model deals with precursors of the standard TPB constructs.

A person's Attitude towards a behaviour is a product of their behavioural beliefs (which are beliefs about the likely consequences of the behaviour) and outcome evaluation (evaluation of how good or bad these outcomes would be). Their Subjective Norm is determined by their normative beliefs (beliefs about what important others (e.g. family and peers) think of the behaviour) and motivation to comply (motivation to comply with this important others) and the Perceived Behavioural Control is the product of control beliefs (beliefs about factors that may ease or obstruct performance of the behaviour) and the influence of control beliefs (perceived strength of these factors) (Warner, 2006; Warner & Aberg, 2006).

The TPB posits that the more favourable a person's standard TPB constructs towards a behaviour, i.e. when people positively evaluate a behaviour, believe that important others think they should perform it and perceive control over it, the stronger will be their Intention to perform behaviour.

Finally, given enough actual control over the behaviour, people are expected to carry out their Intention as soon as an opportunity is given (Ajzen, 1991; Ajzen & Manstead, 2007). However, it is important to note that behavioural control and the normative beliefs people hold towards performing a behaviour are influenced by a multiplicity of situational, personal and cultural factors which will likely differ across contexts and cultures (Warner et al., 2009). This is supported by Ajzen (1991) who argues that the relative importance of standard TPB constructs in predicting Intention will vary across behaviours and situation, as can the importance of Intention and Perceived Behavioural Control vary in predicting a behaviour. Ajzen & Fishbein (1980) propose that, to truly understand the psychosocial and cognitive determinant of peoples' Intention and Behaviour it is necessary to examine the behavioural, normative and control beliefs and their association with the direct theory measures for every study and population through elicitation studies. According to them Elicitation studies help researchers determine salient beliefs of the population and help provide people's thoughts and feelings about a behaviour (for more details about Elicitation studies, see Ajzen & Fishbein, 1980). However, in spite of the importance of salient beliefs in the TPB, there remain methodological and conceptual concerns with the explanatory power of the TPB as most past studies have been limited in the use of the Elicitation studies (Culos-Reed et al., 2001; Sutton et al., 2003).

Overall, reviews of the TPB have revealed plenty of support for its efficacy, explaining between 39 and 27% of variance in Intention and behaviour respectively (Armitage & Conner, 2001).

4.5.1 Application of the TPB to predicting speeding behaviour

The theory has been successfully used as a framework to predict speeding Intention and behaviour (Parker et al., 1992a; Elliot & Thomson, 2010; Pelsmacker & Janssens, 2007; Paris & Broucke, 2008; Tavafian et al., 2011b; Warner & Aberg, 2006; Elliot et al., 2003; Ketphat et al., 2013).

Speed behaviour studies have found significant and convincing correlations between the construct of the TPB (in both original and modified) in predicting the speeding behaviour, although not every variable has been significant in every study.

In one of the earliest studies using the TPB to predict speeding behaviour, Parker et al. (1992a) investigated intentions to exceed the speed limit by British drivers' in 30mph residential zones. They found that it explained 47.2% of variance in intention to speed, with all three standard constructs of the model being significantly independent predictors of Intention. Similarly, a prospective study by Elliot et al. (2003), to predict both intention to speed limit compliance and future behaviour, the TPB explained 48% of variance of intention to speed limit compliance in residential roads, with the results showing that attitude towards complying with the speed limits, Subjective Norm and Perceived Behavioural Control accounted for a substantial proportion of the variance in intention. A combination of Intention and PBC were significant predictors of future behaviour explaining 32% of the variance.

Studies by Letirand & Delhomme, 2005; Warner & Aberg, 2006; Paris & Broucke, 2008; Conner et al., 2007 and Elliot & Thomson, 2010, showed the predictive abilities of the TPB in explaining intention and speeding behaviour with variables accounting for 32% - 82% variance in intention and 28% - 67% in self- reported and measured speeding.

Some studies however did not find some of the variables statistically significant in predicting intention and behaviour. For example Pelsmacker & Janssens (2007) in their study did not find Perceived Behavioural Control either effective on Intention nor Behaviour, to explain this they argued that, control of one's speed varies in different traffic situations. In one of the few studies done in a developing country by Tavafian et al. (2011b) to examine the self-reported speeding behaviour of commercial drivers in

Iran, Attitude towards speeding did not have any significant prediction of behavioural intention. They argue that a positive attitude to speed limit compliance would not necessarily lead one to form the intention to do so, which is supported by Hatfield et al. (2008) who argues that drivers' sometime speed without intending to do so. They concluded that there might be other important factors influencing a driver's intention to speed besides attitude. Ketphat et al. (2013) study to predict the speeding behaviour of young drivers in Thailand, reported that Subjective Norm does not significantly influence speeding behaviour of young drivers. According to them young drivers speeding behaviour is based on their feelings and ability to control driving rather than from family or peers.

In the only study by Newnam et al. (2004) to predict drivers' intention to speed in both work-related and private vehicles with Australian commercial drivers, the TPB was able to explain 27 and 16% of the variance of intention to speed in private and work vehicles respectively, and drivers' attitude was the only predictor of Intention in both settings.

As indicated above, the relationships predicted by the TPB have generally been supported in the speeding domain, and are consistent with the conclusions made by Armitage & Conner (2001) in their meta-analysis of empirical research studies which found the standard TPB constructs explaining close to 40% of variance in intention in a range of social behaviours. However, their study also found Subjective Norm as the weakest predictor in the TPB. This weak predictive power of Subjective Norm within the TPB was argued to be as a result of weakness in the measurement of the variable. Ajzen (1991) proposes that people are more influenced by personal factors than social factors in their intentions to carry out behaviours. Some studies have even proposed for Subjective Norm to be expanded to include Descriptive Norm (refers to individuals' perception of what is commonly done by others) and Injunctive Norm (concerns the moral aspect of whether behaviour is appropriate or not) (Haglund & Åberg, 2000; Pelsmacker & Janssens, 2007).

Chorlton (2007) argued that, though the predictive importance of Attitudes and Subjective Norm has differed across studies, the majority of works have identified Perceived Behavioural Control as the single most important determinant of drivers' Intention to speed.

Widely used models such as the TPB are not without criticism; one of the TPB biggest criticism has been its sufficiency. A number of studies argue that several other construct are responsible for predicting intention and behaviour over and above the TPB constructs (Conner & Armitage, 1998). These studies suggest that the predictive capabilities of the TPB can be greatly enhanced with the some additional variables. Ajzen (1991) clearly stated this "*The theory of planned behaviour is, in principle, open to the inclusion of additional predictors if it can be shown that they capture a significant proportion of the variance in intention or behaviour after the theory's current variables have been taken into account.*" Several additional variables such as, Descriptive norm, normative norm, personal or self-identity, anticipated regret, moral norm, past behaviour/habits, self-efficacy, belief salience, affective beliefs have been found to explain additional over and above the TPB model in driver behavioural studies (Conner & Armitage, 1998; Pelsmacker & Janssens, 2007; Elliot & Thomson, 2010; Ketphat et al., 2013). However, there have also been arguments on the limitations of the additional constructs in the predictive strength and also overlap with current TPB variables, thus, the need for caution in how these extensions are applied. Adam-Guppy & Guppy (1995), argue that anticipated regret may not emerge for many groups of drivers and in all situations. For example, the negative consequences of speed violation related to loss of drivers licence, raised insurance premiums, imprisonment for speed-related deaths, environmental effects, fines etc. may not be salient for Nigerian drivers, thus reducing the overall deterring effect of the contemplation and regret process. On the other hand, anticipated regret may be a strong predictor of intention to comply with speed limits for drivers who work in companies with strong safety culture (as driver's attitude would be potentially more positive to avoid the negative consequences of speed violation which may be fines or loss of jobs), however the same cannot be applied to driver's who work in fleet with less safety culture and in driver's private vehicles (as regret from speeding may be less salient). Parker et al. (1995b), and Newton et al. (2013) argue of a potential overlap between moral norms and anticipated regret. According to them the viewpoint of violating one's moral norms is unlikely to be viewed objectively and will in all possibility give rise to the anticipation of feelings of regret.

Pelsmacker & Janssens (2007) in a study to build and estimate a model that assesses the influence of factors that directly or indirectly determine speeding behaviours using the TPB as a framework, argue that the TPB does not explicitly take into account the affective components of attitude. In line with the widely used definition of Eagly & Chaiken (1993), that describes attitude of consisting of cognitive and affective components, they postulate that both components might have independent effects on the intention to speed. According to them, drivers' may logically accept speeding to be dangerous and wrong (cognitive), but yet may like speeding because of the thrill or the perceive benefits (affective). Or in the alternative a driver may not intend to speed in spite of positive feelings (Affective) associated with speeding if they think they will be apprehended by the police or punished by their employers for speeding (Cognitive). Though they concluded that the cognitive attitude had more impact on the intention to speed, they also propose that a driver's behaviour is not only the consequence of intention but also of Habits. For example, there are times where a driver might be involved in speeding or speed limit violation without any semblance of risk taking made but rather from memory. According to Musselwhite et al. (2010), regardless of whether a person intends or does not intend to drive in a safe manner, habitual processes tend to supersede cognitive processing. It is argued that such behaviours are determined by one's past behaviour rather than by cognitions such as those described in the TPB (Conner & Armitage, 1998). According to these arguments, past behaviour has impacts on future behaviour that are independent of the variables of the TPB (Ajzen, 1991). Speeding behaviour based on the TPB model, is a function of intention of the driver to speed. However when other factors or contexts are involved (e.g. other road users, road factors, time constraint, type of vehicle), drivers' intention and behaviour may likely not align; intentions then might not lead to behaviour (Fleiter & Watson, 2006). As such there has been a need to explain this sometime misaligning intention to behaviour paradox.

Some studies have found past speeding behaviour to be the strongest predictor of intention to speed and the subsequent speeding behaviour (Conner et al., 2007; Elliot et al., 2003) whilst others have shown it to be a significant predictor of intention to speed and subsequent behaviour (Elliot & Thomson 2010; Pelsmacker & Janssens, 2007; Ketphat et al., 2013).

In a study by Musselwhite et al. (2010), among behaviours conducted frequently and in stable contexts, past behaviour was the strongest predictor of future behaviour, whereas among less frequent behaviours conducted in unstable contexts, intention was the stronger predictor of future behaviour. This is because performing a behaviour repeatedly in a stable context leads to the formation of habits, which increases the likelihood of subsequent intentions to being automatically formed and performed (Elliot & Thomson, 2010, Conner & Armitage, 1998). However, Ajzen (1991) argues that the effect of past behaviour is mediated by the Perceived Behaviour Control (PBC), as repetition of a behaviour should lead to enhanced perception of control and regards the role of past behaviour as confirming the sufficiency of the TPB. Pelsmacker & Janssens (2007), concluded that Habit formation and PBC can both partly account for the attitude-behaviour gap, as both influence behaviour directly and indirectly through behavioural intention, though they both measure different things. A driver who speeds frequently on a familiar route in unvarying settings may foster the formation of habits, thus the speeding behaviour may be performed without awareness. In a review by Conner & Armitage (1998), on the empirical and theoretical evidence of additional variables to the TPB construct, the authors concluded that there was empirical evidence to support the addition of these variables; however different combinations of the variables could be added to the TPB construct depending on the behaviour of interest and the aim of the study.

4.5.2 Application of the TPB to behavioural change

Although the predictive validity of the TPB on health behaviour has been significantly established, there is limited literature on the utility of the model in terms of behavioural change (Elliot & Armitage, 2009b; Armitage & Conner, 2002). According to Fife-Schaw et al. (2007) and Stead et al. (2005) many past research that are described as TPB-based intervention studies, only used the model to provide outcome measures against which to track effects, than as tests of the capacity of the TPB variables to promote behavioural change (i.e. not to design the interventions itself).

Surprisingly, only very few studies have manipulated the constructs specified in the model and evaluated whether changes in those variables result in changes in intention and behaviour (for a review see Hardeman et al., 2002)

In the context of driver behaviour, example of such studies include, a TPB-based booklet intervention to increase Cycle helmet use for school children by Quine et al. (2002), TPB-based drama intervention to increase adolescent pedestrian safety (Evans & Norman, 2002).

In the speeding context, such studies are those of Parker et al. (1996) in which an extended TPB framework was used to shape a series of persuasive videos on drivers' speeding on 48kph and 65kph residential speed zones, with results showing only the normative belief video having significant effect in the desired direction and the control belief video having effect in the opposite direction while the behavioural belief video had no measurable effect on altitude. Also the Scottish “Foolspeed” study by Stead et al. (2005), which used series of media advertising campaigns to reduce speeding in urban roads, only the behavioural belief intervention had significant changes in the desired direction with no changes found for the normative and control beliefs intervention. However, the interventions significantly reduced self-reported frequency of speeding compared with baseline levels.

Fife-Schaw et al. (2007), argue that, the relative low performance of TPB-based interventions is because the model is mute on what strategies should be used to change its constructs and also lack of adequate research in this area. Sheeran & Silverman (2003), support this preposition by suggesting that the TPB used in those studies was mainly in forming of motivations, without addressing the processes of transforming those motivations to behaviour (Sheeran & Silverman, 2003). The TPB is mainly focussed on sustaining already formed intentions.

According to Elliot et al. (2005), the TPB based video and media interventions of Parker et al. (1996) and Stead et al. (2002) were not sufficient in bringing the needed change in the underlying cognition due to lack of involvement from participants. Elliot et al. (2005, p. 476) suggest "*classroom-based interventions (e.g., used in the context of driver skills training courses or driver rehabilitation programmes) that allow a high level of interaction between ''student'' and ''teacher'', or interactive computer-based interventions"* would bring attitudinal change that is relatively enduring, resistant and predictive of behaviour.

The researcher is yet to see any TPB-based speeding intervention to have active participation of drivers', thus seek to use the TPB model to design a Speed awareness course (For details of the course see section 8.2.3.1).

4.6 The Unified Theory of Acceptance and Use of Technology (UTAUT)

In the past decade the use of advanced driver assistance systems (ADAS) to improve transport and road safety have been growing rapidly. One such promising system which has been used specifically to reduce speed violation and inappropriate speeding is the one formerly known as "Intelligent Speed Adaptation" now termed "Intelligent Speed Assistant" (ISA). A series of studies have so far been carried out using ISA with positive outcomes showing reductions in mean speeds, reduced speed variability and lower distances/times travelled above speed limit. Whilst most of this research have focused on the technological feasibilities of ISA and the intended impacts, not very much has been done to understand their acceptance and usage (Vlassenroot et al., 2010). According to Adell et al. (2014) the acceptance of advanced driver support systems is important for their usage. They go on to define acceptance as "the degree to which an individual intends to use a system and, when available, to incorporate the system in his/her driving". Thus, acceptance is the combination of behavioural Intention and actual usage if the system is available (Langer, et al., 2017).

Investigating ISA acceptance and its determining factors is very important, because even though individuals or organisations and institutions adopt these systems within their business, they cannot guarantee that these tools are maximising efficiency unless users are using them appropriately (Zakour, 2004).

Adell (2008), in her paper on the concept of acceptance of driver support systems argues that the lack of theory and definition regarding acceptance has resulted in a large number of different attempts to measure acceptance, often with quite different results. Her views are in agreement with Venkatesh et al. (2003, p. 426) who postulate that "*researchers are confronted with a choice among a multitude of models and find that they must "pick and choose" constructs across the models, or choose a "favoured model" and largely ignore the contributions from alternative models*".

Series of technology acceptance models have been used to give insights on the factors that influences user's decisions to use and adopts technological systems when presented with them. One of the most frequently used one especially in road safety and driver behaviour studies has been Ajzen (1991) Theory of Planned behaviour (TPB) which itself is an extension of Ajzen & Fishbein, (1980) Theory of Reasoned action (TRA). (See section 4.5 for details). The TPB has been quite successful in predicting behaviour in a range of settings within different domains and particularly in road safety studies (See Armitage & Conner, 2001 and Warner, 2006 for review), and was specifically used by Warner & Aberg (2006) and Lai et al. (2012b) in ISA-related research). The TPB has also been considered to be ideal in investigating motivating factors involved within the acceptance concept (Vlassenroot et al., 2006). From literature on understanding drivers' ISA acceptance and usage behaviour, the individual socio-psychological factors and system-related characteristics must be taken into consideration. According to Vlassenroot et al. (2006), the TPB is limited in this context, as it only looks at the psychological factors and little social and system influence. Venkatesh et al. (2003) proposed the Unified Theory of Acceptance and Use of Technology (UTAUT), by incorporating eight of the most significant theories in user acceptance and behaviour after reviewing, and empirically comparing the models. Their main aim was to explain users intentions to use an Information System (IS) and further the usage behaviour, by presenting a more complete picture of the acceptance process than previous individual models had been able to do (Alshehri et al., 2012). The synthesized models all had behaviour i.e. use of the new technology as their key elements and are as follows: Theory of Reasoned action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behaviour

(TPB), Combined TAM and TPB (C-TAM-TPB), Model of PC utilization (MPCU), Innovation Diffusion Theory (IDT), and Social Cognitive Theory (SCT) (See Venkatesh et al., 2003 for references). The UTAUT model helps to understand the predictors of acceptance of new technologies, and specifically considers social influences (Polin, 2014).

According to the UTAUT model, Usage Behaviour is directly determined by 'Behavioural Intention' and 'Facilitating Conditions'. Behavioural Intention is in turn influenced by Performance Expectancy (PE), Effort Expectancy (EE) and Social Influence (SI) (Venkatesh et al., 2003). Gender, age, experience and voluntariness of use are posited by the model as key moderators of the impacts of the above mentioned constructs as seen in Figure 14.

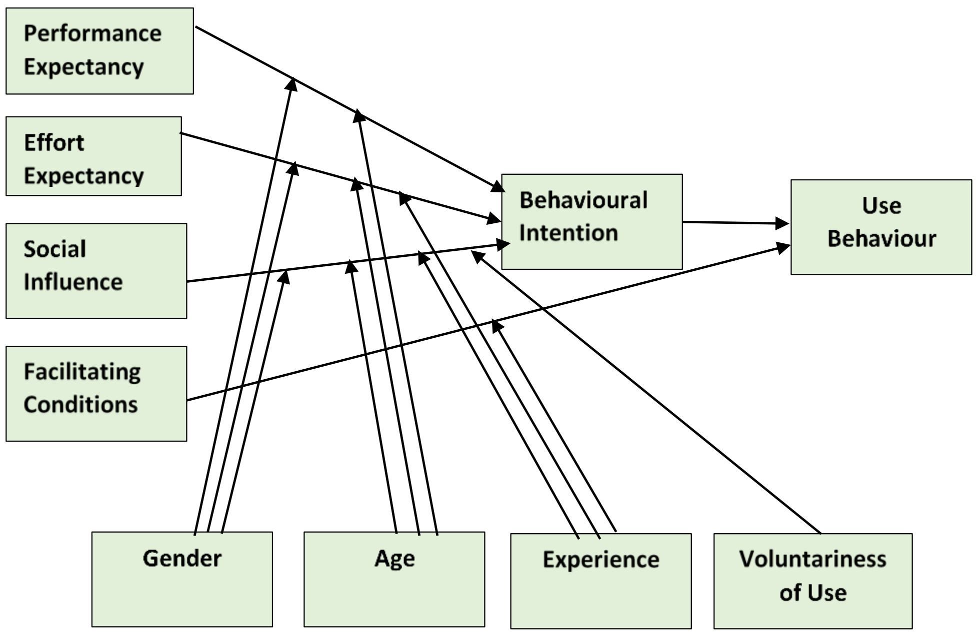

Figure 14: The UTAUT Model (Source: Venkatesh et al., 2003)

According to Venkatesh et al. (2003), the *Performance Expectancy* is the degree to which an individual believes that using the system will help him or her to attain gains in job performance. It is the strongest predictor of behavioural intention and is moderated by gender and age, with effect higher in younger males. *Effort Expectancy* is the degree of ease associated with the use of the system and is in turn moderated by gender, age and experience of the user and more salient in older women but decreases with experience. *Social Influence* is defined by the researchers as the degree to which an individual perceives that important others believe he or she should use the new system.

Gender, age, experiences and voluntariness are the moderators with stronger effects in order women particularly in mandatory settings and little experience. *Facilitating conditions* is the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system. The effect of FC is moderated by age and experience and more significant in older and more experienced users. Results from testing the model's validity on acceptance and use, showed that the UTAUT model outperformed the eight individual models named above, accounting for 70% of the variance (adjusted R^2) in the use as compared with original models where the maximum was around 40%.

The UTAUT model has gained popularity in the past decade and has been used in a wide variety of research domains such as, information/communications, banking, education, health (for review see Taiwo & Downe, 2013; Attuquayefio & Addo, 2014). The appropriateness of the model has so far been supported by these studies and has provided assistance in understanding what factors either enable or hinder technology acceptance and use. The UTAUT model has been responsible for predicting between 20 to 70% variance in intention to use IT or technology (Adell, 2009; Madigan et al., 2016; and Venkatesh et al., 2013).

Although Taiwo & Downe (2013), argue that the UTAUT was mostly cited by researchers to support an argument or used partially, only a few studies used the UTAUT in full.

However according to Adell (2009), the social influence was not found to be as strong a predictor as suggested by the model particularly in the information/Communication and heath domain studies, with modification and extension of the model recommended by the researchers. Also in a review of studies with UTAUT as conceptual framework, Attuquayefio & Addo (2014), did not find any clear patterns of the predictions, though most of the study's results were consistent with the original postulations of the UTAUT model. They found the effect of Performance Expectancy, Effort Expectancy and Social Influence on Behavioural Intention varying across countries, within country and units of studies. They concluded that researchers using the UTAUT model or its extensions should carefully choose the right variables and data analysis techniques.

In another meta-analysis to harmonise the empirical evidence, Taiwo & Downe (2013) argue that past studies appear to be inconclusive in respect of the magnitude, directions and significance of the relationships among the model, which they attributed to the issue of variety in statistical significance associated with the complexity of human behavioural studies in social science, which they say might undermine the accuracy of the models.

In conclusion, Taiwo & Downe (2013) postulate that only the relationship between Performance Expectancy and Behavioural Intention was strong with others slightly weak but significant. For example, the relationship between Behavioural Intention and Usage Behaviour was found to be reliable, while the relationship between Facilitating Conditions and Usage Behaviour was rather less than desired.

4.6.1 Using the UTAUT Model in the context of driver support systems

Though the UTAUT model was developed in the field of user interaction with Information Technology, it has successfully been used in other work context (Adell 2009). In recent times a few studies have investigated whether the same factors apply in the domain of driver support systems. Although, both domains may share similarities in terms of user interactions with the systems and need to facilitate ongoing task, they also share differences in terms of time of use (driving task having a shorter span) and different social dimensions (driving has more interactions with other humans than information technology) (Adell et al., 2014).

Adell (2009), in a pilot test on the SASPENCE system prototypes in routes in Italy and Spain explored the potential of using the model in the context of driver support systems for the first time. The SASPENCE system was designed to help drivers' keep a safe speed according to road conditions and traffic and a safe distance to vehicles ahead. The original model was applied as far as possible in the prediction of acceptance of the system. Due to experimental constraints, the Use Behaviour, Facilitating Conditions and the moderator's experiences and voluntariness of use could not be included. Linear regression analysis showed that Performance Expectancy and Social Influence had a significant positive effect on Intention to use the system, with PE being the major predictor in line with earlier findings by Venkatesh et al. (2003). However, Effort Expectancy showed no significant direct relation to intention to use the system. The model showed a relatively low explanatory power for intention to use the system at 20% when the independent variables (PE, EE and SI) were included.

The researcher highlighted the importance of the Social Influence construct on behavioural intention in the context of driver support systems, arguing that though there are similarities between information technology systems (for which context the UTAUT was developed for) and drivers' support systems, there exist important differences between how the two systems are used, particularly the operational level. According to Adell (2009), "*driving demands more interaction with other road users hence its stronger social dimension*", while the ease of using a computer demands more action from the user than a driver support system that normally runs on its own, hence the low prediction of the Effort Expectancy construct of the model. In conclusion the researcher proposed the addition of emotional reactions of the driver, such as driving enjoyment, irritation, stress and feeling of being controlled. She also suggested that the constructs be weighed according to their perceived importance and including reliability issues in the model.

In a study by Lai et al. (2012b) to understand the effect of advisory ISA on drivers' choice of speed and attitude to speeding, an extended UTAUT model was used as the framework for measuring acceptability of ISA. The additional variables of Attitude towards technology, Self-efficacy and Anxiety were added to the original UTAUT constructs. The study found numerous significant correlations between the UTAUT constructs indicating they may be measuring the same underlying acceptability. Results showed consistent and highly significant patterns over time. There was significant decrease in Facilitating Conditions, Social Influence, Behavioural Intentions and Anxiety, which according to the authors was due to initial preconceptions of using the ISA system being replaced by evidence-based opinions. They conclude that emotive factors rather than ease of use was the predictor of usage of the system.

Madigan et al. (2016) used an adapted UTAUT Model to predict usage of Automated Road Transport Systems. The model was able to explain 22% of the variance in Behavioural Intention, with all three constructs (PE, EE and SI) being significant in the prediction and PE being the strongest predictor. They concluded that the current state of the Model is limited in the determination of factors that influence Intention to use driver assistance systems.

In a more recent study by Langer et al. (2017), the model was used to assess the acceptance of an Intention Detection system to assist drivers' in lane changing. The model explained 46% of the variance in Intention. Social Influence was the only significant predictor of Intention against the researcher's expectations.

Although past studies adopting the UTAUT model in driver behaviour particularly the speed behaviour are limited, the power of the model in assessing technology acceptance should not be undervalued. According to Al-Qeisi (2009) research is yet to establish if technology acceptance models developed in western nations are fully transferrable or applicable in other nations, therefore the need to continue investigation on the effectiveness of the UTAUT model in different socio-cultural context. A number of social-psychological models have been developed to explain and predict technology acceptance. Example include the Technology Acceptance Model (TAM) by Davis

(1989) and its extension TAM2 by Venkatesh & Davis (2000). However, their use has been limited to the acceptance of information systems and often in an organisational context. Also, the models have been reported to have an inconsistent relationship among their constructs (Venkatesh et al., 2003). The UTAUT model, on the other hand, is considered a more robust tool for investigating individual-level technology adoption (Madigan et al., 2016), and was built through the incorporation of eight individual user acceptance models and synthesised into an acceptance model (Venkatesh et al, 2003).

4.7 Chapter summary

The review of literature within this chapter has highlighted various socio-cognition models that are used in driver behaviour related research, and their explanation of underlying psychological mechanisms involved in speeding behaviour. The applicability and efficacy of the TPB model on driver speeding behaviour is well demonstrated, though not without its limitations in terms of sufficiency in predicting. There is limited evidence regarding TPB-based speeding interventions as change instrument, instead majority of the studies are focused on predicting intentions and behaviour. The reviewed studies all differ from each other in their focus and context and have been mostly carried out in Europe, North America, and Asia. To the best of the candidate's knowledge, there is no TPB-based intervention that has objectively measured its efficacy on drivers' speeding behaviour.

Although published studies adopting the UTAUT model in the context of driver acceptance of ISA systems, and other driver support systems remain scarce, and particularly so in low-income nations, this does not undervalue the utility of the UTAUT model in the prediction of Intention to use the systems.

The current study will seek to apply the model in the investigation of acceptance of an advisory ISA by Nigerian drivers, which serves the individual level adoption of the technology.

Chapter 5: Intelligent Speed Assistance (ISA)

5.1 Overview

The field of Advance Driver Assistance Systems (ADAS) is rapidly growing worldwide. These systems offer the potential for significant enhancements in driver and road safety and operational efficiency, both in terms of diversity of applications and also due to an increasing interest in their acceptance. One type of ADAS that received a lot of attention in the last two and half decades is the Intelligent Speed Assistance system (ISA).

This Chapter provides an overview of ISA, summarising of a number of key studies on the use and impact of ISA, and how it has affected drivers' speeding behaviour, safety and cognition.

5.2 Existing speed reducing measures

Despite evidence of the relationship of speed and crash risk and severity (Elvik et al., 2004), speeding continues to be a pervasive driving behaviour around the world (Fleiter & Watson, 2006). Drivers speed for a variety of reasons, such as, for the thrill, time-saving values (Adams-Guppy & Guppy, 1995; Gabany et al.,1997), pressure from peers and from perceived control (Quinby et al., 1999). Other reasons include the lack of awareness of the current speed limits, habitual speeding behaviour and from poor speed calibration (Young et al., 2010).

To encourage reduction of drivers' speed, policy-makers all over the world have used different methods. These include;

Enforcement. These include Police surveillance, speed cameras, fines, and additional points on the driving licence, which are aimed solely at drivers who exceed the speed limit, and involve the use of punishment or deterrent (Hauer et al., 1982).

Education. Including publicity campaigns and messages via the media or at designated locations (e.g. using Variable Message Signs) and speed awareness courses. The objective of these is to alter drivers' attitudes about speeding, in general or remind them of the correct limit for the road conditions, and consequences of speeding (Stead et al., 2005).

Engineering. These include, perceptual measures, and the use of various road-based measures such as speed humps, rumble strips, chicanes, narrowing of lanes, use of markings, and inclusion of reduced speed limit. The main aim of these is to have a direct effect on reducing driver speed (see Comte, 2001 for review).

Many of these traditional speed management measures have been effective for reducing speeding (See Comte, 2001 for a review). However, these countermeasures, tend to only have only local effect, which are limited in time and space (Várhelyi, 1997; Comte et al., 1997; Ghadiri et al., 2013). They are also financially expensive (cost of project expenses, implementation and maintenance), and not always economically feasible. For example, studies have shown that drivers' speed tends to decrease only when they are near enforcement areas, or upon encountering physical speed calming structures, and quickly regain speed once they have passed the intervention sites. This phenomenon is termed the "halo effect", which according to Elliot & Broughton (2005) refers to the length of time that the effects of enforcement on drivers' speed behaviour continues after the intervention is removed (time halo) or the distance that the effects of the intervention last after drivers pass the intervention site (distance halo). This suggests that the effect of the intervention can only be found during a given period of time and/or at a certain distance from the spot where the speed enforcement is carried out. For example, a study by Keenam (2002), found that the mean and 85th percentile vehicle speeds had returned to pre-camera levels by 500 metres downstream from fixed cameras. Also, Elliot & Broughton (2005), found that a time halo effect of physical policing methods vary largely, ranging from effect lasting 1 hour to 8 weeks after the police activity has ceased, while a distance halo effects of stationary policing appears to be in the range of 1.5 miles (2.4km) to 5 miles (8km) from the enforcement site.

Although these traditional speed interventions can help modify driver's' speeding behaviour, they are dependent on the environment and context specific (are not tailored to the behaviour of the individual drivers). There has therefore been a growing desire to control vehicle speed using technologies from within the vehicle (Comte, 1996), and in the words of Archer & Aberg (2001), "*the best way to approach the speeding problem is to treat it at the source (i.e. at the vehicle or road-user level).*

In recent years, the use of novel and promising in-vehicle systems for speed management have been researched, and new technologies used to reduce excessive and inappropriate speeding in developed nations. One such strategy has been the use of Advanced Driver Assistance Systems (ADAS), such as Intelligent Speed Assistance (ISA).

5.3 Evaluating Intelligent Speed Assistance system

ISA is a form of intelligent transport system that serves to limit the speed of a vehicle, or provide advice about the appropriate speed (Carsten & Tate, 2005). An ISA system brings the speed limit information into the vehicle, by helping drivers adapt their speeds to a static or dynamic speed limit (Lai & Carsten, 2012; Warner & Aberg, 2008).

For the system to function as an intelligent unit, the vehicle must know which road it is on, and in which direction it is travelling, and be able to compare this with information on applicable speed limits and current vehicle speed. ISA systems function by establishing the position of the vehicle, using the Global Positioning System (GPS) and comparing the vehicle position with a digital road map that contains information of the local speed limits and responds if the speed limit is reached, or exceeded, by giving in-vehicle feedback to the driver.

Most ISA systems are classified according to their level of configuration and automation, ranging from ‘advisory’, ‘warning’ or ‘informative’ systems, which simply convey information about the current speed limits to drivers, warning them if the limit is exceeded by audible and visual signs. Systems can also be limiting or intervening, which physically limits the speed of the vehicle to the current speed limit, by interfering with the vehicle controls, either via an active throttle (reverse pressure on throttle if the speed is exceeded) or adjusting the engine speed, or braking control, among others. According to Warner (2006), advisory systems primarily affect drivers’ speeding behaviour that occurs due to unintended errors, while intervening systems affect speeding behaviour that occurs due to unintended errors and deliberate violations.

Studies have used these advisory/ warning/ informative systems in different ways. For example some studies have used systems that only provide warnings, (Brookhuis & de Waard, 1999), whereas others provide both warnings and speed information (Lai et al., 2012b).

An intervening ISA can be categorised based on the strictness with which its control is applied. Examples include a **Voluntary** systems (using haptic/active accelerator), where a counter pressure through the accelerator pedal is applied when the speed limit is exceeded. This can be overridden by applying sufficient force). The **Mandatory** system (dead accelerator) describes a system where the vehicle’s maximum speed limit is the same as the road position’s speed limit. This system prevents the driver from exceeding the speed limit and drivers cannot override the system (Carsten & Fowkes, 2000; Carsten & Tate, 2005; SWOV, 2010).

A different range of speed limits system can be used with the ISA, from a fixed speed limit (the posted speed limit of a location), variable speed limits (the speed limit is dependent on the location, with additional speed limit information of special locations such as construction sites, bends, vulnerable road users etc.) and dynamic speed limits (the speed limit is based on the actual road and traffic conditions, including traffic volume and weather, and also dependent on time), (Carsten & Fowkes, 2000; SWOV, 2010).

Since the first study on such in-vehicle system was carried out in France (Saad & Maleterre, 1982), extensive work has been done using Intelligent Speed Assistance systems in the United Kingdom (Carsten & Fowkes, 2000; Chorlton & Conner, 2012; Lai & Carsten, 2012), France (Driscoll et al., 2007), Sweden (Almqvist & Nygard 1997; Biding & Lind, 2002; Várhelyi et al., 2002), Belgium (Vlassenroot et al., 2007), Australia (Regan et al., 2005; Young et al., 2010), The Netherlands (Brookhuis & de Waard, 1999; Oei & Polak, 2002; Van der Pas et al., 2014 and Malaysia (Makhtar et al., 2012; Ghadiri et al., 2013).

Most of these studies have been carried out using different systems, methodologies, data collection techniques and different groups of drivers. The studies all differ in scale, time period and number of participants used. Almost all have revealed positive effects of ISA: such as speed reductions; reductions in fuel consumptions, and volume of emissions, as well as providing safety benefits in terms of reduced fatal and injury crashes. This Chapter will provide an overview of the individual studies, based on: their impact on speeding behaviour; road safety, and driver cognitions.

5.3.1 Impact of ISA on speeding behaviour

Various methods have been used to present the changes in drivers' speeding behaviour in different ISA trials. According to Saad et al. (2004) and Liu et al. (2012), the level of change in speed is dependent on the type of road and the variant of system being used, with the more intrusive systems having higher speed reduction effects.

Conventional descriptions such as mean speeds, speed variances and 85th percentile speed are typically used as the measure of change. However, more recently with second-by-second GPS data providing detailed track of the movement of individual vehicles, the effects of interventions on drivers' speed can now be investigated based either as a proportion of the time the vehicles travel on the network, or the proportion of the distance travelled by the vehicle between two points.

The first reported ISA study was carried out in France by Saad & Maleterre (1982), (as cited by Comte et al., 1997; Warner, 2006; Driscoll et al., 2007). The study involved the use of a speed limiting device, where the vehicle speed limit was manually set by the drivers. However, it can be argued that technically, this was not an ISA, since the device did not have information about the local speed limit, and this speed could not be exceeded, unless the device was disengaged by drivers. Results showed that drivers adapted their speed, based on the surrounding traffic, with most drivers setting their speed above the legal speed limit. The device was less frequently used in roads with lower speed limits (40km/h and 80km/h), and more frequently used in 110-130km/h roads.

There then appeared to be a brief hiatus in ISA research, until the mid-nineties. In one of such study, conducted in The Netherlands by Brookhuis & de Waard (1999), a warning (no speed information) version of an ISA system was tested. Twenty four subjects drove instrumented test vehicles over a fixed route with different speed restrictions, and then performed a similar test in a simulator. Overall, results showed that the system reduced average driving speed by 4km/h. The amount of time drivers drove above the speed limit was also significantly reduced, by 10%, and a large degreed of speed variability was also reported in this study.

Using a large scale trial of ISA from 1999-2002, the Swedish National Road Administration (SNRA), tested three different variants of ISA systems in four municipalities of (I) Umea, where the system provided both audio and visual warming feedbacks when the posted speed limit was exceeded; (II) Borlange, where the ISA informed drivers about the posted speed limit, in addition to audio and visual warnings during violations; III) Lund, where an over-ridable system or active accelerator which provided counter pressure to the accelerator pedal was used; and IV) Linkoping, where a combination of the Borlange and Lund systems was used.

Over 10,000 drivers (average age of 52) and 5,000 cars (Borlange: 400, Lund: 290, Lidköping: 150 and Umea: 4000 vehicles) where used in this study. Results showed effects on speed differed very little between the systems. Speed limit violation reduction ranged from 10-20% across the different systems and speed limit zones. Mean speed fell by up to 3-4km/h for each of the systems. The results also suggest markedly reduced 85th percentile speed in the range 1.5-7.6 km/h across different road types, and also reduction in speed variability in Lund. In the city of Umea which had the highest number of trials, there was no significant reduction in speeds on 70km/h roads, mean speed was reduced by up to 0.9, and 0.7km/h in the 30 and 50km/h roads respectively.

Overall, the warning and informative systems were the most preferred among the participants and general public (Biding & Ling, 2002).

In the UK, studies on examining driver behaviour in response to ISA began in the late nineties, with the External Vehicle Speed Control (EVSC) program, funded by the Department of the Environment, Transport and the Regions (Carsten et al., 2006). The study involved the use of both a driving simulator and on-road ISA equipped vehicles, using different variations of the system, ranging from; advisory, active voluntary (or over-ridable), and active mandatory.

Results from the driving simulator studies showed that systems had little impact on drivers' mean speed, but reduced maximum speeds (Carsten & Fowkes, 2000). On road trial results with the voluntary and mandatory ISA showed that the mandatory systems showed greater impact in terms of transforming the speed distributions (virtually eliminating top end speeds), (Carsten & Fowkes, 2000).

The EVSC program was followed by the ISA UK trials, commissioned by the Department for Transport (DfT) (Carsten et al., 2006), to investigate the potential use of a more "mature and well-integrated" ISA on all road categories. This involved field trials with car fleet, limited on-road trial with an equipped truck, adapted motorcycles and simulator experiments with a voluntary ISA systems.

Results showed reduced mean speed between 0.6 – 4.7 mph across 30, 40 and 70 mph roads. Also there was statistical reduction of 85th percentile speed between 2.4-6.9 mph across 20, 30, 40, 50 and 70 mph roads. Reductions in proportion of speed violation were between 6-11.1% across the 30, 40, 50 and 70 mph roads (Carsten et al., 2008).

The Australian Transport Accident Commission (TAC) SafeCar project (Regan et al., 2005) was designed to evaluate on road trials of various vehicle-based safety functions, one of which was an advisory ISA. The study involved 23 drivers who each drove an instrumented vehicle, covering a distance of over 16,500km over a period of 6 years.

Results showed that ISA alone was effective in reducing mean speeds by up to 1.4km/h in 60 and 100km/h sped zones. The ISA systems also reduced 85th percentile speeds by up to 2.7 km/h in 50, 60, 70 and 100 km/h speed zones. Results also showed a significant reduction in speed violation and speed variability by up to 57% and 1.1km respectively (Regan et al., 2005; Regan et al., 2006a).

The first ISA trials in Belgium started in 2002, in the city of Ghent. The study was aimed at evaluating the effect of active accelerator pedal on speeding behaviour, across different speed zones. Results showed a reduction in the 85th percentile speed and speed variability across all speed zones, by up to 1.7 and 2.5 km/h, respectively. However, a reduction in mean speed was only observed in the 90km/h zone, with this zone also showing the highest reduction in total distance spent speeding (10% reduction) (Vlassenroot et al., 2007).

Following these successful and promising outcomes, in the last decades, the concept of ISA has spread across the globe. Examples include a study by Arhin et al. (2008), who investigated the effectiveness of an Advanced Vehicular Speed Adaptation System (AVSAS) in a driving simulator, in the USA; He et al. (2015) investigating the impact of an auditory speed warning system for commercial passenger vehicles in Wuhan, China; and trials in Malaysia (Makhtar et al., 2012; Ghadiri et al., 2013) and South Africa (Akpa et al., 2016), where an Advisory ISA tested has been tested for use in long distance public transport. These studies have all shown positive outcomes in terms of reducing driver speed.

When comparing the different variants of ISA systems, studies have shown that the intervening ISA systems are much more effective in reducing speeding than the Advisory ISA systems (Paatalo et al., 2001). The intervening systems are able to enforce complete compliance with the speed limits, whilst the usage of the Advisory systems is limited to drivers' choice. Drivers are, therefore, sometimes inclined to turn these systems off, providing an opportunity to speed (Biding & Lind, 2002). Research suggests that the Advisory ISA is more acceptable to drivers', compared with the intervening systems, which are characterised by low user acceptability (Spyropoulou et al., 2014).

Whilst there have been some observed negative behavioural effects from the use of ISA, such as reduced headway with the lead vehicle, (Varhelyi et al., 1998; Carsten & Fowkes, 2000), and an increased travel time (Varhelyi et al., 1998; Ghadiri et al., 2013), the overall effect of ISA on speed limit compliance and speeding has been positive.

The next section outlines how this lowering of speed has been shown to affect road safety.

5.3.2 Impact of ISA on road safety

Determining the impact of ISA on traffic crashes and fatalities is not simple, because the number of vehicles used in most ISA studies is usually quite small, and in order to get a better picture of the effects of ISA on crashes reduction, it important to use a larger number of vehicles, for a longer period of time (Agerholm, 2008a; SWOV, 2010). Also, the complex nature of crashes, and the lack of detailed reporting makes it quite difficult to assess the impact of ISA on road safety (Comte, 2001).

Archer & Aberg (2001), propose that the greatest effect of ISA on mean speeds will occur when around 20-25 of vehicles are equipped with an ISA. These numbers are also based on the influence of ISA-equipped vehicles on the speed of other, unequipped, vehicles. Generally, however, past studies have shown that there is potential for ISA to reduce mean speed and speed differentials, both of which are related to the risk of crash occurrence and the severity of injuries.

Thus, ISA systems can be assumed to have an impact on the reduction in number of crashes, and the severity of injuries. According to Lai et al. (2012a), the Power models (Elvik et al., 2004), and Risk Curves (Kloeden et al., 2001) can be used to establish how ISA can be used to assess the benefits of ISA for reducing rash risk and changes in crash severity.

Varhelyi (1997) investigated the impact of ISA implementation under varying road and lighting conditions. Using the Power Model of Nilsson (2004), he concluded that if an ISA with dead accelerator was fully implemented, an optimistic estimate of between 24-42% reduction in the number of injury-crashes will result.

Biding & Lind (2002) used the Power Model in their evaluation of the road safety benefits of ISA in the Swedish trials. They estimated a 20-25% reduction of injury crashes and 23-32% in fatal crashes if all vehicles in the areas studied were equipped with ISA.

Carsten & Tate (2005) predicted the crash savings of different types of ISA from the UK external vehicle speed control (EVSC) project. They used three different models in their approach (Finch et al., 1994 (overall relationship between changes in speed and changes in injury accident numbers); West & Dunn, 1971(adjustment was applied to take into consideration the effect of changes in speed variance with certain types of ISA); Anderson & Nilsson, 1997 (predictions of the effects on injury accidents were used to calculate the impacts on more serious accidents). Carsten & Tate (2005), concluded that in a best case scenario of 100% ISA penetration, an advisory Fixed ISA will produce 10 and 18% reduction for injury and fatal crash respectively. Implementing a mandatory dynamic ISA was predicted to save 36% of injury crashes and 59% of fatal crashes.

The Australian TAC SafeCar study (Regan et al., 2005), reported an estimated reduction in fatal and serious injury crashes by up to 9% and 7%, respectively if an ISA had combined advisory, warning and intervening properties and implemented on a large scale.

In the French LAVIA ISA, experiments (Driscoll et al., 2007; Ehrlich, 2009) were carried out with three variants of ISA (advisory, voluntary and mandatory). This study estimated that at 100% penetration, the advisory system would reduce serious crashes by 2-3%, and fatal crashed by 4-7%, per year. The voluntary system was estimated to cut serious and fatal crashes by 1-11%, and 3-17%, respectively, whist the Mandatory system was estimated to reduce fatal crashes by 5-16% and all serious injury crashes by 3-9%.

Finally, the Malaysian advisory ISA study by Ghadiri et al. (2013), estimated a 13% reduction in the number of serious injury crashes, and 17% decrease of fatal accidents as a result of system implementation.

Therefore, it is clear from the above-mentioned empirical analyses that the road safety benefits resulting from the use of ISA are considerable, and likely to be maximised with 100% implementation of this system. However, the effect of ISA on accident reduction is dependent on the variant used and the road type. Mandatory ISA has so far shown the greatest potential of accident reduction across all road types, and particularly on urban roads (because crashes on these roads involve vulnerable road users) (Lai et al., 2012a).

However, some caution must be taken when estimating these benefits, since differences exist in the type of ISA system used, the design of each study, and differences in analysis techniques (Driscoll et al., 2007).

The next section will provide a summary of how drivers' attitudes are affected from the use of ISA.

5.3.3 Impact of ISA on drivers' attitudes

There have been extensive studies investigating the effects of ISA systems on drivers' speeding behaviour, generally illustrating positive results, and showing that the use of ISA systems in all its forms (advisory to intervention) brings about a significant reduction in speeding and the follow up safety benefits. However, only a few of these studies have examined the impact of ISA on the cognitive variables of speeding behaviour as proposed by the TPB (Warner, 2006; Chorlton & Conner, 2012; Chorlton, 2007).

Using social-psychological models of behaviour, research has so far shown that drivers' speed choice is dependent on their beliefs and attitudes towards speeding (Conner et al., 2007 and Elliot et al., 2007). Since ISA studies have often shown that speed limit compliance does not necessarily increase travel time (Comte & Carsten, 1999), according to Chorlton (2007), actual experience with ISA may serve to modify drivers' beliefs relating to perceived gains from speeding, producing positive cognitive changes. Chorlton & Conner (2012) also propose that drivers' underlying psychological factors such as beliefs and attitudes to speeding can be changed, or modified, with the provision of continuous speed limit information, or by imposing vehicle control, to reduce speed.

Chorlton & Conner (2012) investigated the long-term impact of ISA on drivers' speeding cognitive variables using the TPB. Their study found that experience with ISA translated to increased intention of drivers' to speed limit compliance and revealed positive changes in their beliefs with significant reduction in speeding, however like past studies, the reduction was short term. They concluded that, for ISA to have longer and sustained behavioural effects, there is a need to augment this effect with other interventions such as educational campaigns. This view is supported by Liu et al. (2012), who propose that for a long-term speeding behavioural or cognitive change, an ISA system needs to be implemented in conjunction with other behaviour change strategies to reinforce longer term changes.

According to Warner (2006), long-term use of the warning ISA system in the Belgium trials (Borlange) resulted in a significant difference in how the test drivers' rated their attitude towards exceeding the speed limits as well as their Perceived Behavioural Control. After three years of usage, the test drivers' held significantly less favourable attitudes towards speeding and significantly perceived they had greater control over complying with the speed limit. However, at the same period self-reported speeding remained the same, suggesting that the small changes in the predictors were not sufficient to produce a change in intention and behaviour.

In another warning ISA study by Lai et al. (2012b), the TPB was used to track changes in drivers' cognition relating to speeding. Results showed that driver's motivation to keep to speed limit reduced over the period of the trial. Though drivers were overall disposed to positive attitudes towards keeping to speed limits, there was a decline over the course of the trial. However, the system increased drivers' self-efficacy (their ease and confidence in being able to keep to the speed limit).

Hjalmdahl (2004) identified that a supportive ISA system had an effect only on drivers' with positive motivation towards the system and who normally where speed limit compliant, suggesting that intention is a prerequisite for behavioural performance as stated by the Theory of Planned behaviour. Lahrmann et al. (2012) conclude that the impact of ISA on driver's choice of speed is dependent on their intention to comply with the speed limits.

5.4 Chapter summary

The evidence reviewed above suggest that ISA offers the prospect of reducing speeding and improve road safety. However, despite the ability of the system to modify speeding behaviour, its effect on drivers' cognition is limited to only period of use. If changes must be sustained beyond trials, there is need to augment the system with other intervention strategies.

Although research on ISA systems have gained a considerable amount of empirical evidence over the years, their effects on driving behaviour in low-income countries needs to be measured. Since previous trials were mostly carried out in middle and high-income countries and exclusively on privately owned vehicles, there is need to test their efficacy in Low-income countries where their impacts on injuries and fatalities might be greater. There is also need to compare their effects with other speed reduction interventions.

Chapter 6: Elicitation of drivers' beliefs to speed limit compliance (Study 1)

6.1 Overview

Anecdotal evidence suggest that drivers' exhibit different sets of attitudes and behaviours in work and private driving. This chapter describes a qualitative study designed to elicit beliefs relating to speeding among drivers' who work in fleet companies with strong safety culture.

The Theory of Reasoned Action (TRA) and its extension The Theory of Planned Behaviour (TPB) posit that individuals' salient beliefs about the consequences of performing a behaviour (attitudes), beliefs about the views of significant others and beliefs about the factors that facilitate or impede the performance of a behaviour are direct determinants of Attitude, Subjective Norm and Perceived Behavioural Control respectively which in turn independently predict intention to perform the behaviour. See Chapter 4 for literature.

According to Ajzen & Fishbein (1980) and Ajzen (2006), behavioural interventions that seek to change beliefs that guide performance of the behaviour, must first identify specific salient and accessible beliefs from sample respondent that are representative of the population of interest. The measurement of such beliefs is premised on the fact that; the understanding about these beliefs, the more likely an effective intervention can be developed to influence behaviour by providing understanding into the underlying thoughts and perceptions in relation to the target behaviour (Abdul et al., 2012).

Fishbein & Manfredo (1992) propose that people's beliefs about a behaviour will always vary and more importantly from population to population as beliefs cannot be assumed to be transferable among different populations. Thus, the need for elicitation studies to be carried out wherever the TPB is to be used either as a framework for designing interventions or for measuring the efficacy of interventions (Curtis et al., 2010).

According to Ajzen (2006) these beliefs can be elicited through a series of open-ended questions, with responses undergoing content analysis using most frequently cited beliefs used in the final intervention. The assumption is that if a belief is not mentioned, it is not salient, as only accessible beliefs in memory are salient (Ajzen & Fishbein, 1980).

Whilst there have been considerable developments in interventions and research on changing drivers' speeding behaviour via change in beliefs and cognitions, they seem to have been limited in their impacts as the behaviour continues to be a norm (Elliot et al., 2005), Parker (2002) suggests that the content of such campaigns could have been more a result of the imagination and inspiration of the organisers or researchers than of any theoretical framework.

In spite of the importance of salient beliefs in the TRA/TPB, the elicitation stage has received relatively little attention from researchers, therefore the current study aims to extend on previous research on the TPB framework by seeking to elicit the salient behavioural, normative, and control beliefs underpinning speeding behaviour among fleet drivers' with the aim of incorporating this understanding to inform the development of targeted anti-speeding training. No specific hypotheses were tested as the study was rather exploratory, thus the study sought to address one research question:

RQ1. What are the underlying beliefs towards speeding among Nigerian drivers'?

6.2 Methods

6.2.1 Participants

A total of thirteen (13) drivers participated in the study in one of three focus group discussions. The sample consisted of only male drivers within the age range of 30-65 (mean age of 36.4). The drivers' were randomly selected from two fleet companies that are sub-contractors to Shell Nigeria Petroleum Development Company after permission had been granted by the fleet companies. Participants all reported exceeding 10,000 km annual mileage and owned a drivers licence.

6.2.2 Procedure

The researcher commenced each session expressing his gratitude to the participants for their time and attendance of the meeting. Participants were then given verbal introduction by the researcher that emphasised the parameters of the behaviour with respect to context of speeding and speed limit compliance. To minimise bias, participants were assured of the confidentiality of their responses which would be anonymous, hence only honest opinions and answers being sought, and that there were no right or wrong answers, with every thought and opinion well appreciated and valued. Participants were then given the study information sheets and consent form, which had brief demographic questions about their age, annual travel mileage and years of driving experience.

Throughout the discussions, the researcher encouraged participants to share their views and opinions and enacted active listening skills. Discussions were guided by a schedule of open-ended questions, and the researcher continually invited participants to share their thoughts by asking them if they had any other information when discussions went quiet. Discussions continued until no new information was being raised and lasted for about 60 to 80 minutes. At the end of the discussions, participants were thanked for their time and contribution. The questions within the schedule were based on the belief categories of the TPB (see Table 2).

The discussions were audio recorded and transcribed verbatim removing any identifying details. Prior ethical approval had been granted by the Research ethics committee of the University of Leeds.

Table 2: Elicitation of beliefs semi-structured questions

Behavioural Beliefs	- What do you think are the advantages of speeding? - What do you think are the disadvantages of speeding? - What do you like or enjoy about speeding? - What do you dislike or hate about speeding?
Normative Beliefs	- Are there any groups or people who would approve of you exceeding the speed limit or speeding? - Are there any groups or people who would disapprove of you exceeding the speed limit or speeding?
Control Beliefs	- What factors or circumstances will make it difficult for you to engage in speeding? - What factors or circumstances will make it easy for you to engage in speeding?
Intention	- Do you think you will speed or exceed the speed limit in the future?

6.3 Data analysis

The transcribed data were coded using a data matrix by grouping participants responses about speeding into each of the relevant beliefs (i.e., behavioural, normative, control) and additional responses for their intention and then the most frequently beliefs noted. Each of these beliefs is discussed together with supporting statements in the form of quotes from participants. To protect participant's confidentiality, each quote was presented in this thesis only in relation to the order in which the participant had first spoken in the discussions and the group number. For example the third participant to speak in the second focus group would be identified as (P3, 2).

The data were analysed using Deductive Content Analysis (DCA), which is a systematic and objective means of describing phenomena (Krippendorff, 1980). According to Hsieh & Shannon (2005), the DCA method is mostly used when the structure of the analysis is based on an existing framework or theory, and previous knowledge of the study area. It involves a structured matrix development whereby all data are reviewed for content and coded for correspondence to the identified categories (Polit & Beck, 2012). For example in the current study, the Behavioural, Normative and Control beliefs were coded. Results are then described by the content of the structures describing the phenomena, for example, speeding (Elo et al., 2014).

Table 3 shows the most frequently cited beliefs by correspondents within each of the TPB constructs. Only salient modal beliefs (i.e. most commonly cited beliefs) are shown in the table in accordance with Ajzen & Fishbein (1980) rule of including only beliefs that exceed 10-20% of the sample population.

Table 3: Salient accessible beliefs

BEHAVIOURAL BELIEFS			
Positive Instrumental (Cognitive) evaluation	**Negative Instrumental (Cognitive) evaluation**	**Positive Affective Evaluation**	**Negative Affective Evaluation**
- Helps me reach my destination quicker. - Helps me in time of emergencies. - Saves my life in times of security threats.	- It causes accidents and fatalities. - Causes damage to vehicle and properties. - It uses more fuel, hence causing harm to the environment. - Puts other road users at risk - It makes it hard for me to quickly stop my vehicles when there is an obstacle on the road.	- It makes me excited - It thrills me (It is fun) - It helps keeps me awake and alert. - It helps me arrive on time	- It pricks my conscience - It makes me nervous - Causes damage to vehicles and loss of life - It causes accident
NORMATIVE BELIEFS			
Approval	**Disapproval**		
- Male Friends and peers	- Family members / Children - Employer - Road safety authority		
CONTROL BELIEFS			
Impediments	**Facilitates**		
- Presence of Police or Road Safety officers - Driving in heavy traffic - Presence of Speed bums - Driving in poor weather - Driving Faulty vehicles - When driving with passengers who want me to drive slow - Driving in built arears - Driving in curvy roads	- When in less traffic - When driving in good roads - When late or in a hurry - When having personal emergencies - When drunk - When driving a sound vehicle - When driving on a wide and straights roads		
INTENTION			

- If there is need or a reason, I would exceed
- If there is an emergency I will speed
- I will speed unintentionally if excited

When I don’t know the speed limit I will speed.

6.4 Results and discussion

6.4.1 Behavioural beliefs

In order to elicit instrumental beliefs, participants were asked questions about the advantages and disadvantages of speeding. To elicit their affective beliefs, participants were asked to list what they like or enjoy/dislike or hate about speeding. The results showed some overlap between instrumental and affective beliefs. In particular, causes of accidents, loss of life and reduced journey time appeared in both set of beliefs.

Various disadvantages of speeding were raised among participants; however the risk of crashing, loss of life and injuries, damage to vehicle and properties were the most elicited with all participants mentioning them.

In the words of participants

"*Speeding is a hydra-headed enemy of life, it is an enemy I hate it" (P4, 2).*

"The expenses are higher on a high speed; Human life is at stake, the tear and wear of the car are higher, you even use more fuel when you speed. In short the more the speed the faster the aging of the car" (P1, 1)

Thus in relation to the disadvantages linked with loss of life and vehicle damage, it may be relevant for anti-speeding interventions to depict the trauma a driver causes to other people when life is lost in a crash, and the monetary cost to himself. Giving the strong perception of damage to car and properties as an undesirable outcome of speeding, speeding interventions can show the consequences of losing one's car or damaging another person's car or properties through the stress of missing a bus or taxi (Loss of freedom/control over ones travel decisions) or having to pay high insurance and in Nigeria where Insurance isn't much of a thing, having to pay for the repair or purchase of another person's car and your car as well.

The following positive evaluations of speeding were readily identified by participants in all groups; reduced journey times, making up time for late schedules and saving of life in emergencies or security threats were the most elicited beliefs. Such findings brings the need for speeding interventions in Nigeria to raise drivers' awareness of the misperception of time saving, showing them that speed does not represent a means to save or make up time (Regan et al., 2005) and also highlight the need for better time planning strategies by drivers. Drivers' beliefs about the excitements and fun that comes with speeding can be highlighted through, *“In addition to testing the strength of my car, there is fun in speeding, it is more of a challenge when you driving and someone drives pass you. You pick up a challenge I need to pass this person, my car is better than his car. If I drive slowly in long distance journeys, I tend to fall asleep. Am usually more alert when am driving fast” (P4, 3)*

The latter comment reflects the perception that speeding removes boredom and increases enjoyment. Such positive affect of speeding in terms of heightened situation awareness has been identified in past studies (Abdul et al., 2012; Horvath et al., 2012; Lewis et al., 2013). Such findings highlights the role of enjoyment driving to places, in drivers’ choice of speed. Thus the need for speeding interventions to emphasize that keeping to speed limit or not speeding put you in more control, making you more attentive and mindful of the driving situation (Abdul et al., 2012; Lewis et al., 2013).

6.4.2 Normative beliefs

With speeding clearly a socially undesirable behaviour, all participants identified the role of significant others that would not approve of their speeding, with family members being consistent across all groups. Others include the opinions of employers and road safety agencies.

“When I drive with my elder brother it is always boring as he wants me to drive a maximum 70-80km. It gets me sick sometimes” (P1, 3).

“Sometimes passengers do not approve of my speeding; Example my wife and family members tend to stop me from speeding by telling me to slow down” (P2, 3).

Since beliefs about family members disapproval was consistent among participants, intervention could highlight close ones who have died or got injured as a result of speeding (Lewis et al., 2013) and also highlight how the society sees a speeding driver.

Significant others who approved of their speeding were either male friends or their peers similar to findings from Horvath et al., 2012 study. For example;

“I have a cousin who by default always speeds. When you drive with him and some of my friends and you are not speeding, the next thing is they ask you to pull over and they will drive the car” (P2, 3).

6.4.3 Control beliefs

Participants across groups identified various factors that will ease and impede their speeding behaviour. Driving in built areas, congested roads, presence of enforcement agents, speed bumps and driving on roads with speed signs were relatively consistent across the groups as inhibiting their speeding.

"I tend to drive within the speed limit whenever I am with my family members" (P4, 3).

"Whenever I drive the company vehicle I am very mindful of the speed limit and I try to stay within the limits" (P2, 2).

On the other hand, less traffic, being in a hurry or being late, personal emergencies and driving on straight and wide roads appeared as the most frequently mentioned facilitating beliefs to their speeding.

"When the road is good and there is less traffic I sometimes speed more" (P3, 2)

Interventions can be developed which challenge drivers' beliefs that speeding in roads with less traffic or empty roads is safe, as most participants hold the perception that they are in control of the behaviour when the conditions seem safe. According to Lewis et al., (2013) "*such (mis)perception could be challenged by a message that illustrates how things can go wrong, even when conditions are seemingly safe*". This will involve interventions highlighting the unpredictability of some circumstances and the need for drivers' to give themselves the best chance to remain in control by not speeding. The use of in-vehicle speed monitoring devices such as intelligent speed adaptation devices (ISA) may serve as a potential strategy for increasing drivers' control of the behaviour, especially in conditions that appear relatively safe to them.

Even though it is beyond the scope of this study to review evidence relating to strategies for reducing speeding when faced with life threatening personal emergencies (e.g. when family members need medical help or when attacked or tailgated by criminals). It is important to note that there is poor delivery of emergency services in most low-income countries, leaving individuals to take themselves to hospitals in emergencies or also due to poor security situations in most of these countries, some routes are bedeviled with miscreants. However, a pertinent issue to note is, the need to recognize that driving above the speed limit under such condition can even cause more harm to the sick relative or even increase the chances of a crash.

6.4.4 Intention

Participant's motivation to speeding was elicited by directly asking respondents if they intended to perform the behaviour in the future. With speeding clearly socially undesirable, responses from such a questions were likely to be biased.

Most of the participants expressed their intention to comply with the speed limits. However, some participants across groups gave instances where they will speed ranging from: Emergencies to unintentional speeding.

“I might be compel to, by circumstances, I don’t want to, I don’t like it, but I could be compelled to. E.g. there is need for me to get out of a place fast, I will move fast “(P4, 1).

“The truth is that, in Nigeria the absence of road signs create lot of confusion among drivers’. Because if you are travelling on a road that is well signalised with speed limit, any time I see the speed limit it enters my consciousness and it guides me. But since we have too much pot holes on our road, the slightest chance of good road, I will speed to make up for lost time” (P1, 3).

6.5 Conclusions and research implications

The focus groups discussions not only saved time in terms of data collection, they provided an opportunity for participants to actively exchange anecdotes and experiences relating to speeding and speed limit compliance, and in the process a total of 17 Behavioural beliefs, 4 Normative beliefs, and 18 Control beliefs were elicited from the study.

According to Curtis et al. (2010), people’s beliefs are influenced by many factors and can either be personal or environmental. The behaviour of driving above the speed limit or driving too fast for the condition may appear to be similar among different population. However the underlying beliefs towards the behaviour are usually different and appear to have been affected by the target population and location. This can be seen in findings from this study revealing some evident differences in beliefs with past studies. For example, participants in this study believe that speeding helps them in times of emergencies or security threats (“*In my own understanding, the advantages of speeding depends on the environment you find yourself. If you are on emergency e.g. a medical emergency or if you driving on road that is dangerous you have to speed for security purpose to avoid being attacked by bandits* or thieves” *(P2, 2),* Or they speed mostly when the road is in good shape (*“When the road is good and there is less traffic I sometimes speed more” (P3, 2)*.

Nigeria like most developing nations is struggling with serious security challenges, and drivers’ are sometimes forced to drive above the legal speed limit on some routes to avoid being caught up with criminals or even communal clashes. Lack of good road networks also create opportunities where drivers’ tend to exceed speed limit in other to make up for lost times driving in bad spots.

The above are some location and situational factors that could have resulted in the formation of salient behavioural and control beliefs among the drivers'. Therefore, issues of social pressures should be considered when developing speeding interventions in developing countries like Nigeria.

The current study have provided interesting insights that could have both theoretical and practical implications, and could add to the limited database of elicitation phase in behavioural change research as it is usually either overlooked and underestimated (Curtis et al., 2010).

For example the findings revealed that, overall, speeding was perceived as an adverse behaviour with negative consequence. However participants still held some advantages for performing the behaviour. As in previous studies (Ferguson et al., 2009) participants specified that most important others will disapprove of speeding, but similar to studies by (Horvath et al., 2012; Lewis et al., 2013), participants believed that male peers would approve of their speeding. Beliefs that good condition of the road and car and bad state of the road will both facilitate and impede speeding, respectively, were expressed by the participants.

The findings from this Study have provided greater understanding into a range of beliefs influencing speeding behaviour, with particular focus on the beliefs of drivers' who work under strong speed compliance regime in a developing nation.

Although further research may be needed to develop effective speeding/speed limit compliance interventions, practical suggestions to guide the developments of such countermeasures have been offered to challenge those salient beliefs in this Study.

While the current Study has revealed drivers' underlying beliefs towards speeding, their true attitudes and behaviour can only be assessed through a follow-up measurement phase based on the TPB. Thus, all salient modal beliefs (beliefs mentioned most by the participants) elicited from the study were incorporated into the design of the Speed Awareness Course (SAC) and used to prompt discussions during the interactive session. For example, elicited beliefs by participants were added to the list of positive and negative outcomes of speeding. Also elicited beliefs were included in the volitional sheet used during the speed awareness course.

In conclusion, the insights offered by this Study 1 are potentially relevant in the application of the TPB in influencing change in drivers' speeding behaviour. The strategies provided in the study may serve as key aspect in interventions targeted at drivers' who work in companies with strong safety culture but hold different set of attitudes in their private vehicles. This is because, though they might obey speed limit regulations when driving work vehicles (likely from anticipated fear of losing their jobs), their salient beliefs are favorable towards the behaviour and in turn will predict their behaviour in private driving. To improve overall fleet safety, drivers' salient speeding beliefs should be targeted in interventions with a resulting carryover effect in their fleet driving.

6.6 Limitations and future studies

Though Ajzen & Fishbein (1980) argue that the use of a small sample for an elicitation study is appropriate, there is still concern on the representation of the beliefs on the broader fleet population. It should be noted that after the third focus group discussion, no new beliefs were mentioned by the participants indicating that three group discussions with 13 participants were sufficient to elicit most commonly held beliefs associated with speeding and speed limit compliance.

Given that the beliefs identified from the sample drivers are specific to drivers' who work in fleet companies with strong safety culture and with the participants all being older males (age 30-65), it cannot be assumed that this beliefs would apply in the younger driving population. A general elicitation study of drivers' from the general public will be required in the future.

Chapter 7: Understanding drivers' speeding cognition (Study 2)

7.1 Overview

This chapter describes Study 2 of the research program. The aim of the study was to establish the differences in cognitive variables associated with speed limit compliance as enumerated by the Theory of Planned behaviour (TPB), in drivers' who work in fleet companies with strong safety culture. More specifically, these drivers' exhibit a different set of Attitudes, Subjective Norm, Perceived Behavioural Control (PBC), Intentions and Self-reported behaviour in their work vehicles compared with private vehicles. The study also explored the combined impact of a Speed Awareness Course (SAC) and use of an Intelligent Speed Assistant (ISA) system by drivers' on their TPB variables.

While there have been several studies examining the efficacy of the TPB, the majority have focused on predicting intentions and behaviour to speeding among the general population of drivers' (Parker et al., 1992a; Elliott & Thomson, 2010; Elliott et al., 2004; Paris & Broucke, 2008; Stead et al., 2005) with little focus on work or occupational drivers specifically. There have only been two previous studies assessing the TPB model in relation to work related drivers (Newnam et al., 2004; Poulter et al., 2008), with the former assessing the predictors of speeding intentions in both work and private vehicles in a cross-sectional study, whilst the latter examined the ability of the TPB to explain truck drivers' general driving compliance behaviour.

To the best of the candidate's knowledge, this study is the first time the predictive utility of the TPB have been used to investigate the Intentions to speed limit compliance and Self-reported behaviour of work-related drivers prospectively. The study also seeks to investigate the relationship of driver's TPB variables and their observed speeding behaviour.

The focus of Study 2 is to address three of the research questions mentioned in section 2.3.

RQ2: What are the cognitive variables which predict drivers' intention and self-reported speeding behaviour when driving their work and private vehicles?

RQ3: Will the differences in their intention to speed limit compliance in work and private vehicle reflect the differences in their Attitudes, Subjective Norm and Perceived Behavioural Control?

RQ4: Will the combined intervention of ISA and SAC have any effect on drivers' cognitive variables?

RQ5. Will there be any relationships between TPB variables and the objectively measured speeding behaviour?

The results of Study 2 are presented in this chapter, and overall offer a comprehensive theoretical-based investigation of speed limit compliance of drivers' who work in a fleet company with strong safety culture with a view to providing insights into their behaviour for both work and private vehicles.

7.2 Methods

7.2.1 Participants

Participation in Study 2 required the completion of a self-report survey at two time periods.

To participate at Time 1, participants needed to have the following;

(i) Possess a driver's licence.

(ii) Drive a work vehicle for a fleet company with strong safety culture weekly.

(iii) Drive a private vehicle weekly.

(iv) Had no prior experience with the speed warning system.

(v) Had not been involved in any speed awareness course in the 6 months prior to the study.

To participate at Time 2, must meet the following requirements:

(i) All requirements in Time 1.

(ii) Drivers have undergone the speed awareness course and driven with the ISA system as part of the research.

A total of 68 participants were involved at Time 1 and 20 participants at Time 2.

7.2.2 TPB questionnaire measure

Past general population speed-related studies have either used direct or belief-based measures of the TPB variables, as they are assumed to act as a measure of the same constructs (Ajzen & Fishbein, 1980). Direct measurement is done by means of an item set of evaluative semantic differential scales. Example of questions include: "respecting the speed limit is advantageous/disadvantageous*"* (Attitude), "family members would think I should speed 10km/h above the speed limit" (Subjective Norm), and "I find it difficult to keep to speed limits when the road is good" (Perceived Behavioural Control). Belief-based measures are created by the product of outcome beliefs and outcome evaluations. Example of questions includes: "If I exceed the speed limits the risk of me losing my driving license will increase" (behavioural belief strength), and "to increase the risk of me losing my driving license is good/bad" (behavioural outcome evaluations). While both methods have been found to significantly predict speeding intention; direct measurement (e.g. Elliott et al., 2003 and Newnam et al., 2004), belief-based measurement (e.g. Parker et al., 1992a and Elliott et al., 2005), it has been suggested that direct measurement may provide a more powerful prediction of Intention than belief-based measurement (Manstead & Parker, 1995). Warner (2006) argue that the former allows for a relatively small number of items which can cover a larger percentage of variance of intention. For this study, the direct measurement approach has been adopted as it captures highly accessible spontaneous evaluations easily than the belief-based measures (Chorlton, 2007).

Following an elicitation study (outlined in Chapter 6), standard items used in previous studies (Parker et al., 1992a; Newnam et al., 2004, Stead et al., 2005) were used to measure the construct of the TPB, and self-reported speeding behaviour in a prospective self-completion survey. All items were measured using 5-point scales (Scored 1-5). Each construct was measured with respect to speed limit compliance on urban and highways. To reduce response bias or tendencies of social conformation (Paris & Broucke, 2008; Hart et al., 2005), some items were negatively phrased. The same set of items were used for each vehicle setting (Fleet and Private) and each time period (pre-intervention and post-intervention).

The questionnaire was based on a scenario methodology used in previous studies (Parker et al., 1992a; Newnam et al., 2004) "*You are alone in a work/private vehicle speeding down a residential street (built area) with cars parked down both sides. It is 4 o'clock on a fine and dry afternoon. The road has a 50 km/h speed limit. However, you are driving at 65km/h.* See appendix A.1 for copy of the questionnaire.

All reversed-scaled items of the questionnaire were recorded in the same direction. A high score reflecting more of the given constructs. For example, a high score indicates a favourable Attitude, supportive Subjective Norms, greater Perceived Behavioural Control and favourable Intention to speed limit compliance.

Attitudes, Subjective Norm and Perceived Behavioural Control served as the independent variables, whilst Intention to engage in speed limit compliance and Self-reported behaviour were the dependent variables.

7.2.3 Procedure

A prospective cross-sectional survey design was utilised, which featured a within subject design involving 2 time periods. A total of 150 questionnaires were distributed to a sample of fleet drivers' working with Shell Petroleum Development Company, Port Harcourt Nigeria, designed to act as a baseline (Pre-intervention) condition. These questions included measures of all TPB constructs, as well as self-reported behaviour.

As noted earlier, Study 2 had two phases. The Time 1 questionnaires was designed to examine the TPB variables before the interventions, while the Time 2 questionnaire assessed the TPB variables after the interventions, 12 weeks later. Participants were randomly assigned to two groups after the baseline period, in order to counterbalance the different interventions.

Participants were provided with information and definition of terms. Example*, work vehicle driving;* driving in any work-related vehicle or situation, *private vehicle driving*; driving personal vehicles or any non-work related vehicle, *Speed limit violation*; any occasion where you are travelling above the speed limit in either urban arear (50km/h) or highway (80km/h). Instructions were given on the need for responses, to be honest, and data anonymity was assured to the participants. Time 1 questionnaires were distributed at the participant's place of work to be completed at home and returned the next day to the researcher. Time 2 questionnaires were given to participants on completion of their final drive, and to be completed at home and returned next working day as most drives were done during the weekend.

A 45% (N=68) return rate was achieved at Time 1 and only 29.4% (N=20) were involved in the main study and completed the questionnaire at Time 2.

A post intervention survey (Time 3), was sent out to investigate the cognitive variables, 9 months after the Time 2, but the data received was not sufficient to carry out any meaningful analysis, as only a few of the participants were available to provide responses. This was due to changes in personnel. All questionnaire were completed anonymously without any identifiers and took between 15 and 20 minutes to complete.

7.3 Data analysis

All data were analysed using the Statistical Package for the Social Science (SPSS Version 22) and Microsoft Excel (Version 2013). Before analysis, data were screened for accuracy of entry. Overall, there were no missing data for items from the questionnaires returned.

7.3.1 Demographic statistics

In addition to the TPB questions, demographic questions such as participant's age, driving experience, mileage, vehicle type were assessed. These demographic variables were measured for descriptive and control purposes.

Table 4 shows that only male participants were involved in the study demonstrating that fleet and commercial driving is an exclusively male dominated sector in Nigeria. At Time 1 all participants were above 25 years with over 82% within the age bracket 36-55. The majority of the participants had driving experience of 15 years or more (72%). 85% of the participants have worked with their current employer for over 5 years. Majority of the participants reported driving below the 10 hour per day limit in both work and private vehicle. 91% of the participants drove cars in their private vehicles compared with the 48.5% in work vehicle.

The majority of the participants who participated in the on-road study and subsequent survey, were aged 36 and above (90%). In terms of driving experience, 75% of them had owned licences for over 15 years with 85% of them having worked for over 5 years with their current employer.

Table 4**:** Demographic Characteristics of participants for Time 1 and Time 2 surveys

Time 1 (N=68)						**Time 2 (N=20)**					
Age	**%**	**Licence (Years)**	**%**	**Working experience with SHELL (Years)**	**%**	**Age**	**%**	**Licence (Years)**	**%**	**Working Experience with Shell (Years)**	**%**
26-35	10.3	8-15	27.9	0-4	3	26-35	5	8-15	25	0-4	15
36-45	38.2	16-20	30.9	5-15	38.3	36-45	45	16-20	25	5-15	25
46-55	44.1	20+	41.2	16-20	25.0	46-55	45	20+	50	16-20	35
56-65	7.4			20+	22.1	56-65	5			20+	25

Time 1 (N=68)						**Time 2 (N=20)**					
Weekly driving	**% Fleet**	**% Private**	**Hourly driving/week**	**% Fleet**	**% Private**	**Weekly driving**	**% Fleet**	**% Private**	**Hourly driving/week**	**% Fleet**	**% Private**
≤ 3 times	11.8	22	≤ 10 Hours	36.8	30.9	≤ 3 times	-	20	≤ 10 Hours	25	30
4-5 times	41.2	22	11-20 Hours	22	42.6	4-5 times	35	20	11-20 Hours	15	40
Everyday	13	56	21-30 Hours	23.5	10.3	Everyday	65	60	21-30 Hours	30	5
			≥ 30 Hours	17.7	16.2				≥ 30 Hours	30	25

Time 1 (N=68)						**Time 2 (N=20)**					
Mileage (Km)	**% Fleet**	**% Private**	**Vehicle**	**% Fleet**	**% Private**	**Mileage (Km)**	**% Fleet**	**% Private**	**Vehicle**	**% Fleet**	**% Private**
≤ 5000	10.3	16.2	Car	48.5	91.2	≤ 5000	15	15	Car	65	90
5000-15000	38.3	60.3	Bus	16.2	4.4	5000-15000	25	55	Bus	15	-
15000-30000	23.5	5.9	Pickup Truck	19.1	1.5	15000-30000	35	-	Pickup Truck	5	5
> 30000	27.9	17.6	>one vehicle	16.2	2.9	> 30000	25	30	>one vehicle	15	5

Exploration of background variables between the two groups 20 volunteers and 48 non-volunteers revealed the two groups were similar with respect to age, licence ownership and mileage. The group differences were small and none were statistically significant.

7.3.2 Measures of validity and reliability

Preliminary analyses showed that several measurements were not normally distributed and therefore a non-parametric test was used in the analyses of the data.

The internal consistencies of the scale were measured using the Cronbach Alpha coefficient (α), which according to Nunally & Bernstein (1994) should be above 0.70 to reliably measure a construct.

The Principal Component Analysis (PCA) was used to establish the validity of the TPB constructs. The PCA according to Norusis (2008) is the simplest method in which linear combinations of the observed variables are formed. The choice of the PCA was hinged on its ability to summarise most of the original information (variance) in a minimum number of factors for prediction purposes (Hair et al., 2006), and its lack of assumption concerning an underlying causal structure for co-variation in the data (Hatcher, 2003).

An initial Principal Component analysis (PCA) was run on all 32 items measuring the constructs of the TPB, and self-reported behaviour. Results showed that by inspection of the correlation matrix three variables did not have correlation coefficients greater than $r=0.3$ and were reducing reliability (Cronbach's α) of the proposed structure. Further examination showed that they had small variance on the components, hence were subsequently removed. On re-run of the items, the overall Kaiser-Meyer-Olkin (KMO) measure of 0.76 verified the sampling adequacy for the analyses, and according to Hutcheson & Sofroniou (1999), it is termed 'Middling'. Overall individual KMO measures were greater than 0.5 which according to Field (2013), is the acceptable limit. Barlett's test of sphericity was statistically significant ($p<0.05$), indicating that the data is likely factorable.

A PCA resulted in 8-components with Eigenvalues greater than Kaiser (1974) criterion of >1, and which was explained in a combination of 75.3% of the total variance. However, visual inspection of the scree plot produced a 4-component solution accounting for 53.6% of the variance. Subjective preference was given to the latter solution. Varimax-rotation solution did not produce any meaningful result as there were inconsistent loading on the four factors.

To decide how many factors to retain, a combination of three principal criteria were used. According to Norusis (2008), the most applied rule is that each component should have at least three variables that load highly on it.

Smith et al. (2007) in their study using the TPB to investigate the interplay of Self-Identity and Past Behaviour, a PCA was performed on the Norm items to ensure that all items (i.e., descriptive and injunctive) loaded on a single factor. This analysis revealed the presence of a single factor only, justifying the creation of a single-norm construct.

In trying to achieve more simple component structures (where each variable has only one component that loads strongly on it), a separate PCA was performed for the items measuring each of the constructs of the TPB, and revealing the following results (see Table 5 for the component loadings).

Attitudes

Eight items were used to measure Attitudes towards compliance with speed limits. (e.g. '' respecting the speed limit reduces the chance to get involved in a crash''). The items measured both cognitive (negative-positive) and affective (satisfying-unsatisfying) Attitudes.

A Principal Component Analysis on the 8 items produced a 3-component solution explaining 66.3% of the variance when using the eigenvalue >1 criterion and a two component solution when using the scree plot. For ease of interpretation preference was given to the latter solution (See Figure 15). A Varimax-rotation resulted in 5 items loading more on the first component explaining 33.9 % of the variance and 3 in the second component explaining 17.7% of the variance. The loading on the components were inconsistent and appeared to be interrelated with a component correlation coefficient of .37 hence the two separate indexes for cognitive or instrumental and affective Attitudes were collapsed to form one attitude scale. Internal consistency for the attitude measure was assessed using Cronbach's alpha and was reasonable. α =.67.

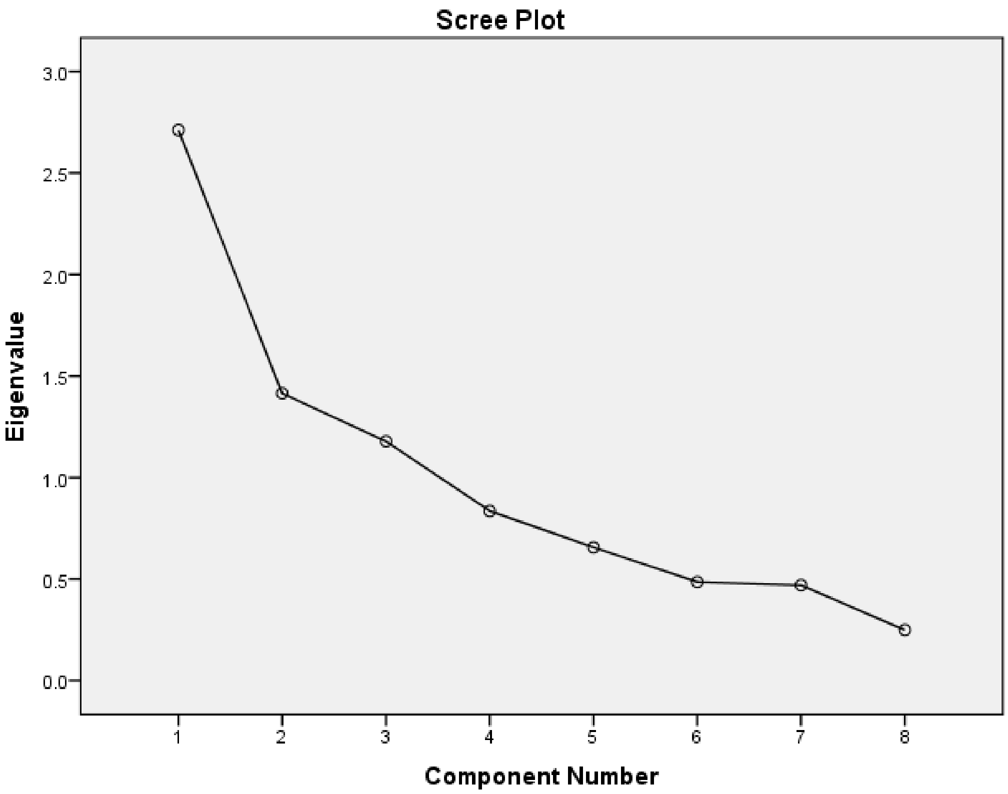

Figure 15: Scree Plot for Attitude Construct

Subjective Norm

Subjective Norm was assessed by 5 items (e.g. “Family members would think that I should speed 10km/h over the limit.’’). Initial Principal Component Analysis of the 5 items showed that one item (‘‘the speed of the traffic around me is more important than the speed limit’’) had no correlation greater than r=.3 and also explained only 2.93% of the variance and was subsequently removed. A re-run of the items produced a one component solution explaining 74.4% of the total variance. This can be explained by the fact that only one variable recorded an eigenvalue above 1, with the scree plot showing a change in the slope of the line between the first and second component. An inspection of the component matrix table shows that all items load strongly on the one underlying component (all above .78). Reliability scores for Subjective Norm was good with α = .88.

Perceived Behavioural Control (PBC)

PBC was assessed using 4 items (e.g. “I find it difficult to keep the speed limit if the traffic around me is going faster than the speed limit.’’). A Principal Component Analysis resulted in a 1-component solution accounting for 55.2% of the total variance for both eigenvalue >1 and scree plot criteria. However, one item ‘‘I find it easy to monitor my speed while driving’’ showed very little correlation (<.3) with other items and only explained 5.627% of the variance, was removed. A rerun of items still produced a one component solution but with higher total variance of 72.6% with correlation between variables on the component all above .51 Reliability scores for PBC was α = .79.

Figure 16: Scree Plot for PBC Construct

Intention

A principal component analysis on the 4 items measuring Intentions to speed limit compliance resulted in a 1-component solution accounting for 95.1% of the total variance for both eigenvalue >1 and scree plot criteria. Correlation between the variables was as high as .903. Reliability scores for the intention scale was α = .95.

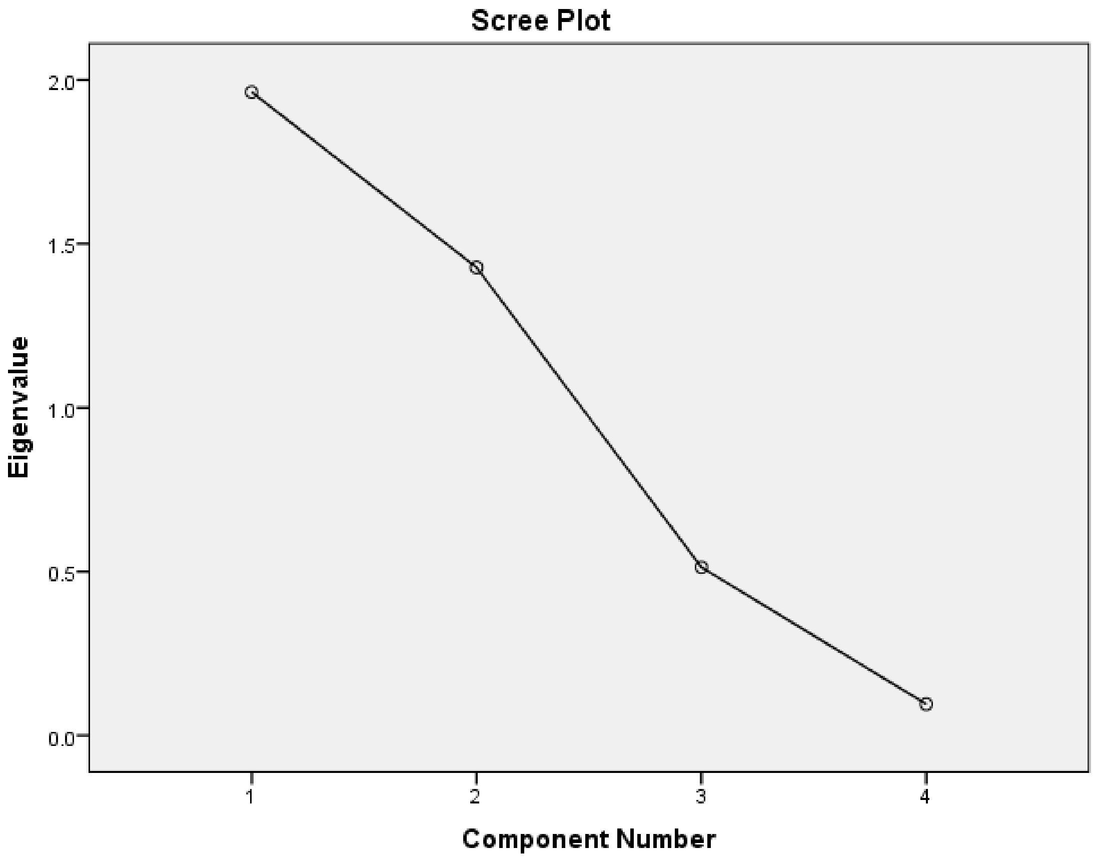

Figure 17: Scree Plot for Intention Construct

Self-reported behaviour

Nine items were used to measure drivers' self-reported behaviour, on a Likert scale ranging from 1 (Never) to 5 (Every time) (e.g. Exceed the speed limit by more than 10km/h on urban roads") A principal component analysis on the 9 items measuring self-reported behaviour resulted in a 2-component solution accounting for 75.6% of the total variance for both eigenvalue >1 and scree plot criteria. An oblique Promax-rotation resulted in 6 items loading on the first component, explaining 61.2% of the total variance and 3 on the second component explaining 14.5% variance. However the loadings appear to be inconsistent between self-reported speeding on urban and highways (more than 3 variables loading on both components). With variables having interrelation above .5 they were subsequently collapse into on scale. Reliability scores for self-reported scale was α = .91.

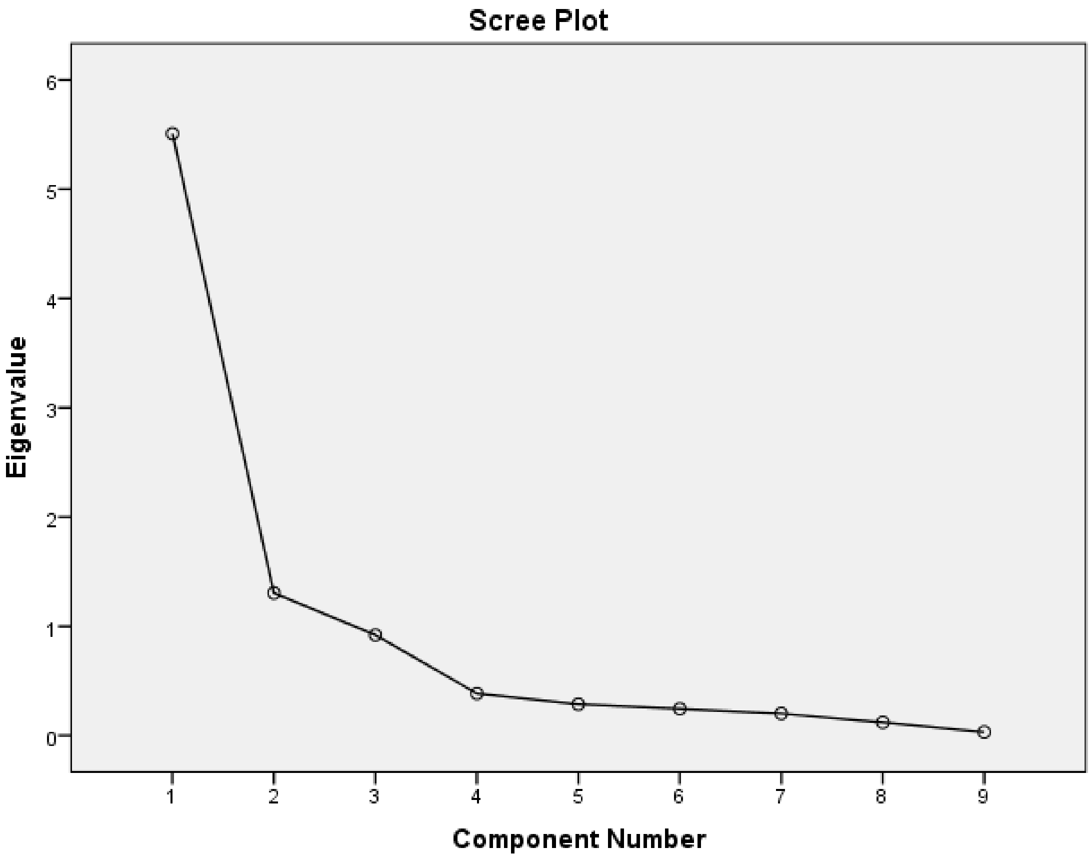

Figure 18: Scree Plot for Self-Reported Speeding Construct

Table 5: Component loadings for TPB items measured

Item	Components							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Attitude								
Respecting the speed limit reduces the chance to get involved in a crash.	.125	**.701**	-	-	-	-	-	-
Respecting the maximum speed limit makes you drive in a more relaxed way.	-.157	**.820**	-	-	-	-	-	-
It is Ok to exceed the speed limit as long as you drive carefully.	**.683**	.273	-	-	-	-	-	-
Exceeding the speed limit would help me arrive my destination more quickly.	**.782**	-.160	-	-	-	-	-	-
It is OK to exceed the speed limit as long as you don't have passengers in the vehicle.	**.619**	.395	-	-	-	-	-	-
Respecting the speed limit makes you need more time to reach your destination.	**.594**	-.153	-	-	-	-	-	-
I would favour stricter enforcement of the speed limit on all roads.	-.283	**.300**	-	-	-	-	-	-
Exceeding the speed limit would make me feel excited.	**.766**	.236	-	-	-	-	-	-
Subjective Norm								
The boss would think that I should speed 10 km/h over the limit.	-	-	**.780**	-	-	-	-	-
Other work drivers' would think that I should speed 10 km/h over the limit.	-	-	**.837**	-	-	-	-	-
Family members would think that I should speed 10 km/h over the limit.	-	-	**.837**	-	-	-	-	-
The police/ FRSC would think that I should speed 10 km/h over the limit.	-	-	**.938**	-	-	-	-	-
Perceived Behavioural Control								
I am more likely to exceed the speed limit if I am in a hurry.	-	-	-	**.749**	-	-	-	-
I find it difficult to keep to the speed limit if the traffic around me is going faster than the speed limit.	-	-	-	**.905**	-	-	-	-

I find it difficult to keep to speed limits when the road is good.	-	-	-	**.894**	-	-	-	-
Intention								
I intend to drive within the speed limit on urban roads.	-	-	-	-	**.975**	.028	-	-
I intend to drive within the speed limit on highways roads.	-	-	-	-	**.973**	.069	-	-
Self-reported speeding								
Exceed the speed limit by more than 10 km/h on urban roads?	-	-	-	-	-	-	**.823**	.215
Exceed the speed limit by more than 20 km/h on urban roads?	-	-	-	-	-	-	**.836**	.368
Exceed the speed limit by more than 10 km/h on highways?	-	-	-	-	-	-	.241	**.949**
Exceed the speed limit by more than 20 km/h on highways?	-	-	-	-	-	-	.196	**.962**
How often do you disregard the speed limit on an urban road?	-	-	-	-	-	-	**.826**	.346
How often do you disregard the speed limit on a highway?	-	-	-	-	-	-	**.833**	.318
Deliberately disregard the speed limit late at night or very early in the morning?	-	-	-	-	-	-	**.808**	.289
Find yourself travelling above the speed limit without realising you are doing it?	-	-	-	-	-	-	**.812**	.083
Not knowing the speed limits of the road you driving?	-	-	-	-	-	-	.345	**.463**

Note: Major loadings for each item are in bold

7.3.3 Correlation of variables

Table 6 shows that at each stage of the survey, the mean scores on each variable were above the midpoint indicating that overall, the participant's Attitudes, Subjective Norm, Perceived Behavioural Control, Intentions and Self-reported behaviour were high.

The results also show that the scores were slightly higher in work vehicle than in private vehicles at both Time 1 and Time 2. There was a slight spread of the scores about the mean as can be seen from the standard deviations.

Spearman correlation shows that participant's Attitudes were positively and significantly correlated with their intentions in both work and private vehicles at Time 1 (r=.438; r=.444). Participants with favourable Attitudes were more likely to intend to comply with speed limits in their work and private vehicles at this stage of the survey. These results are in contrast to the Newnam et al. (2004) study where Attitude and Intention were both negatively correlated in work and private vehicles. This could be a result of the specific sample used in this study. Only drivers who work in a company with strong safety culture were used in this study, as against a wider representation sample used in Newnam et al. study.

Their Subjective Norm was only positively significantly correlated with their intention to comply with speed limit in their work vehicle at Time 1 (r=.314). Participants' important others were supportive of their intentions to comply with speed limits in their work vehicles at this stage of the survey. There was no significant correlation between their PBC and intentions in either their work or private vehicle at Time 1.

At Time 2, the bivariate correlation results showed significance between intention and Attitudes, PBC in only the private vehicles (r=.602; r=.796). In contrast, no significant correlations between intention and any of its determinants were revealed in participant work vehicle at this stage.

Participants' Intentions and PBC were both significantly correlated with their self-reported behaviour at Time 1 in both work and private vehicles (Work r= 260; r=.460; Private r=.423; r=-.283), with PBC exhibiting a negative correlation with self-reported behaviour in the latter vehicles. At Time 2 only PBC showed significant correlation with self-reported behaviour and it was in work vehicle (r=.450). See Table 6 for details.

Participants' Attitudes toward speed limit compliance appear to be more correlated with their intention to perform the behaviour than other determinants and this was even more in the private vehicles.

Overall, the highest correlation was 0.49, which is sufficiently low to rule out multicollinearity (Field, 2013).

Table 6: Descriptive Statistics and correlations for the TPB variables and self-reported speeding behaviour

Time 1: Pre-intervention (N=68)																		
Variable	**Work Vehicle**									**Private Vehicle**								
	Items	**α**	**Range**	**Mean (SD)**	**A**	**SN**	**PBC**	**I**	**B**	**Items**	**α**	**Range**	**Mean (SD)**	**A**	**SN**	**PBC**	**I**	**B**
Attitude	8	.68	1-5	4.32 (0.51)	1.00	-.009	.097	.438*	.101**	8	.68	1-5	4.08 (0.57)	1.00	.086	-.251**	.444*	.493*
Subjective Norm	4	.90	1-5	3.81 (0.97)	-.009	1.00	.526*	.314*	.390*	4	.87	1-5	3.27 (1.05)	.086	1.00	.086	.144	.011
Perceived Behavioural Control	3	.81	1-5	3.81 (1.01)	.097	.526*	1.00	.150	.460*	3	.75	1-5	3.51 (1.00)	-.251**	.086	1.00	-.030	-.283**
Intention	2	.93	1-5	4.58 (0.76)	.438*	.314*	.150	1.00	.260**	2	.98	1-5	4.03 (1.23)	.444*	.144	-.030	1.00	.423*
Self-reported behaviour	9	.74	1-5	4.57 (0.53)	.101	.390*	.460*	.260**	1.00	9	.90	1-5	3.26 (0.95)	.493*	.011	-.283^{b}	.423*	**1.00**
Time 2: Post-intervention (N=20)																		
Variable	**Work Vehicle**									**Private Vehicle**								
	Items	**α**	**Range**	**Mean (SD)**	**A**	**SN**	**PBC**	**I**	**B**	**Items**	**α**	**Range**	**Mean (SD)**	**A**	**SN**	**PBC**	**I**	**B**
Attitude	8	.71	1-5	4.18 (0.57)	1.000	-.139	.297	.309	.324	8	.38	1-5	4.14 (0.41)	1.000	.246	.533**	.602*	.335
Subjective Norm	4	.88	1-5	3.91 (0.95)	-.139	1.000	.058	-.201	0.36	4	.89	1-5	3.87 (1.02)	.246	1.000	.465*	.395	.205
Perceived Behavioural Control	3	.65	1-5	4.27 (0.64)	.297	.058	1.000	.259	.450**	3	.893	1-5	3.78 (1.07)	.533**	.465**	1.000	.796^{b}	.303

Intention	2	.72	1-5	4.62 (0.48)	.309	-.201	.259	1.000	.255	2	.83	1-5	4.20 (0.85)	.602[a]	.395	.796[b]	1.000	.098
Self-reported behaviour	9	.84	1-5	4.41 (0.68)	.324	.036	.450**	.255	1.000	9	.90	1-5	3.6 (0.85)	.335	.205	.303	.098	1.000

Note: A high mean value indicates Attitude, Subjective Norm, PBC and Intention in favour of complying with the speed limit
*= Correlation is significant at the 0.01 level (2-tailed) (p <.01)
**= Correlation is significant at the 0.05 level (2-tailed) (p <.05)

7.3.4 Statistical analysis

With preliminary analyses showing non-normality of several of the measurements and assumptions of the paired t-test having not been met, it was imperative to use a non-parametric test. Data from the different settings and Time period were compared using the Wilcoxon Signed Rank Test (which is the non-parametric equivalent to paired t-test), to examine differences and consistency over time. Data (the difference between the scores of each set of variables) were checked to meet the assumptions of being relatively symmetrical in shape.

7.4 Results and discussion

7.4.1 Predicting Intention and Self-reported behaviour

A multiple regression analysis was carried out for Time 1 data to determine how much variation of drivers' intention to comply with the speed limit is explained by their Attitude, Subjective Norm and Perceived Behavioural Control. The regression analysis was also used to identify the predictors of drivers' self-reported behaviour. According to Tabachnick & Fidell (2007), the recommended sufficiency power for a regression analysis is $N \geq 50 + 8m$ (where m is the number of predictors). Therefore, in order to ensure sufficient power, the minimum sample size required in the current study is 61 and 60 cases for the intention and behavioural based analyses respectively. After the cleaning and screening processes, the sample size which was retained for the regression analyses were N=68 and N=20 for Time 1 and Time 2 respectively. Therefore only the cases in Time 1 were statistically sufficient. Results have only been provided for Time 1 data.

Assumptions: Data were checked to meet the assumptions of regression analysis as recommended by Laerd statistics (2015) and Field (2013). These include; assessment of *independence of observation* using the Durbin-Watson statistics values ranging from 1.5-2.5, assessment of *linearity and homoscedasticity* by visual inspection of plot of studentised residuals and unstandardized predicted values, inspection of the correlation coefficient ($p<.80$) and tolerance values (<0.1) which showed minimal multicollinearity between variables, and assessment of normality of residuals .

Intention: From Figure 19, the model significantly predicted 12.1% of the variance in drivers' Intention to comply with speed limit in their work vehicles, $F(3, 64) = 2.95$, $p= 0.039$ ($p<0.05$) and 24% of the variance in their private vehicles, $F(3, 64) = 6.58$, $p= 0.001$ ($p<0.01$). However, the largest and only significant prediction of Intention was explained by their attitude $\beta = .331$, $p= 0.007$ ($p<0.01$) and $\beta = .50$, $p= 0.0005$ ($p<0.01$)

respectively for work and private setting. This means that drivers' with a positive attitude towards speed limit compliance where more likely to have the intention to perform the behaviour in both their work and private vehicles. Subjective Norms and Perceived Behavioural Control did not significantly contribute to the prediction of Intention at this stage. For details see Figure 19, and Appendix A.8.

The results are partly comparable with several studies that have demonstrated the ability of the basic TPB model to predict speeding intention (Parker et al., 1992a; Elliott et al., 2004; Stead et al., 2005; Newnam et al., 2004; Hanan, 2014). Findings from this study show that Attitudes made a significant contribution to the prediction of Intentions to speed limit compliance in both work (accounting for 12% of variance) and private vehicles (accounting for 24% of variance) at Time 1. These findings are quite consistent with the views of the model, thus, partially supporting H1 which had proposed standard TPB variables will significantly and positively predict intention to comply with the speed limit.

Overall, the standardised beta weights were positive, demonstrating that as Attitudes and PBC increased, drivers' were more likely to report intention to comply with the speed limit. However, this study did not find Subjective Norm to be a significant predictor of Intentions at any stage of the study. This finding was not unexpected or uncommon as past studies by Newnam et al. (2004); Abdul Hanan (2014), Armitage & Conner, (2001) have also identified Subjective Norm to be relatively weak in the prediction of Intention (relative to Attitude and PBC). A potential explanation for this weakness could be that having the support of important others to comply with speed limit would not necessarily lead to forming the intentions to do so. This is supported by Rivis & Sheeran (2003) who argue that Subjective Norm may not entirely capture all the potential normative influences which may be impacting upon an individual, as it focuses only what the individual thinks their important others approve or disapprove. Another possible reason for the poor prediction of Intention by drivers' Subjective Norm is that drivers' are inclined to make decisions from an individualistic perspective, rather than group responsibility (Hanan, 2014). Also, they have been arguments on the need to expand the construct to capture both *injunctive norms* (social pressure on drivers' to perform or not to perform from other road users including vulnerable road users and other drivers) (Haglund & Åberg, 2000), and *descriptive norms* (pressures to imitate other road users or perception of what is commonly done by others) (Haglund & Åberg, 2000; Pelsmacker & Janssens, 2007).

Self-Reported behaviour: Attitude and Subjective Norm were not included in the regression analysis for the prediction of self-reported behaviour. According to the TPB, they can only influence behaviour indirectly via intention. Intention and Perceived Behavioural Control were entered as the independent variables to examine the predictive utility of the TPB constructs in its basic form.

Multiple regression at Time 1 revealed that Intention and Perceived Behavioural Control significantly predicted compliance with the speed limits in private vehicles $R^2 = .440$, $F(2, 65) = 25.513$, $p= 0.0005$, ($p<0.01$). Participants with stronger intentions were more likely to drive within the speed limit while those with greater perceived control were less likely to comply with the limits. Intention had greater contribution $\beta = .620$, $p= 0.0005$ ($p<0.01$) to the prediction of compliance with the speed limit PBC $\beta = -.193$, $p= 0.042$ ($p<0.05$). This finding fully supports H1 which proposed that both Intention and PBC will significantly predict self-reported behaviour in a private setting. The results are also similar to studies by Elliott et al. (2004); Stead et al. (2005) and Abdul Hanan (2014) that demonstrated the ability of the TPB variables to predict behaviour.

In contrast, there was no significant prediction of the behaviour by either Intention or PBC in work setting at Time 1($R^2 = .081$, $F(2, 65) = 2.848$, $p= 0.065$). For details see Figure 19, and Appendix A.8.

There was insufficient power for a regression analysis for time 2 data. Overall, the findings suggest that the TPB model may be better operationalised in the private setting than a work setting. This may be related to the fact that the driver's in this study may have a higher degree of freedom in expressing their held beliefs and behaviour in a private setting than a work setting.

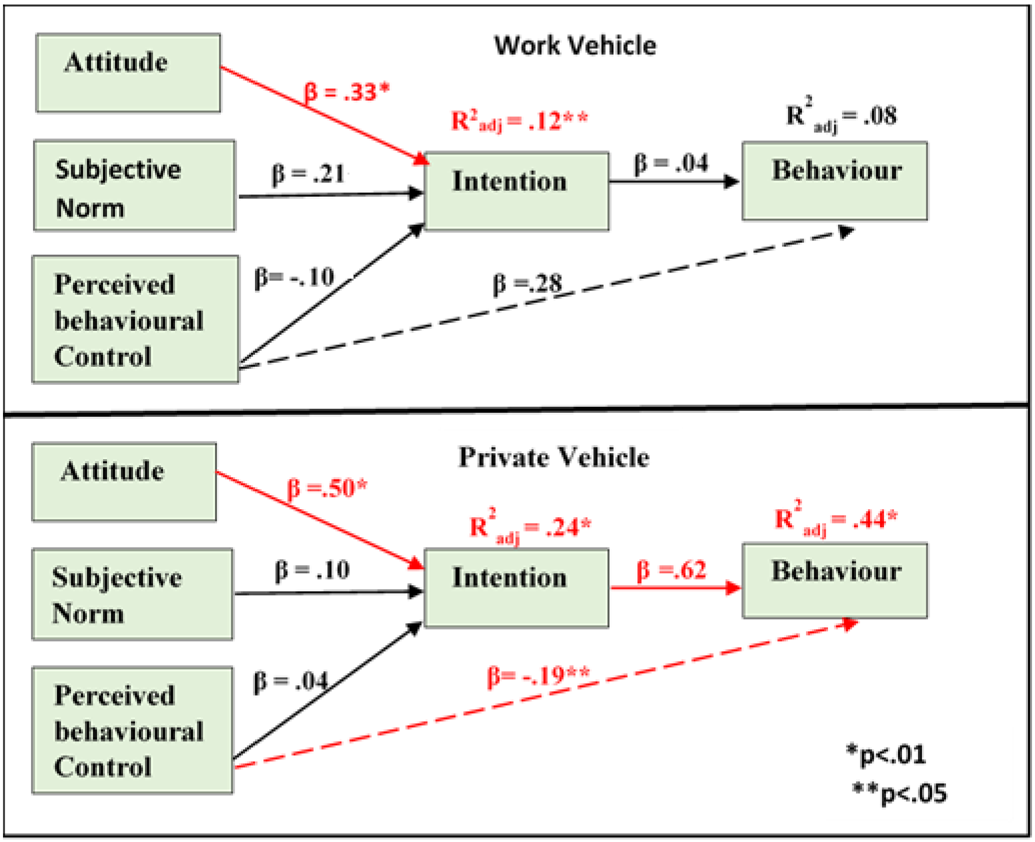

Figure 19: The model, based on the theory of Planned Behaviour with standardised path coefficients and explained variance for intention and self-reported behaviour at Time 1

7.4.2 Comparing TPB constructs between settings (Work Vs Private)

Comparison is only done for the 20 drivers who participated in the study at Time 1 and Time 2.

Time 1: In comparing TPB variables for work and private vehicles at **Time 1**, Wilcoxon Signed Rank Test revealed that a relatively medium to low significant difference exist for some of the TPB variables. The result show that participants were relatively more likely to have favourable Attitudes towards speed limit compliance (z = - 0.748, p=0.045), perceived greater control of their behaviour (z =-2.326, p = 0.020), and self-reported more compliance (z = -3.30, p = 0.01) in a work vehicle than in a private vehicle. There was no significant difference in their Subjective norm and Intention constructs in work and private vehicle. See Table 7 and Figure 20 for more details.

The findings from this study at Time 1 to some extent support H2 which proposes significantly more favourable TPB variables in work vehicles than in private vehicles. In contrast, the findings differ from those of Newnam et al. (2004) who reported significantly higher Intention by driver's to speed in their private vehicles than in work vehicle. Also Newnam et al. (2004) found a low but significant difference was found between a work and personal vehicle for Subjective Norm. One possible explanation for this difference in findings is the use of only drivers who work in a company with strong safety culture in this study, compared with the Newnam et al. study which involved drivers' from organisation with extensive and less extensive safety regimes. It also seem reasonable to assume that due to the difference in context (participants in the study are from a LMIC country) and the nature of the study in promoting speed limit compliance, a behaviour that is highly favourable by their company safety policies, participants in this study were more likely to portray themselves in good light in work vehicles than in private vehicles.

Time 2: At this time, the results revealed a low, but significant difference in participants' PBC ($z = -2.532$, $p=0.011$), Intentions ($z = -2.532$ $p= 0.011$) and Self-reported Behaviour ($z=-2.984$ $p= 0.03$) between work and private settings. Participants' at Time 2 were more likely to have more positive Intentions, greater perceived control of their behaviour and actual performance of the behaviour in a work vehicle than in private vehicle. However, there were no significant differences identified for Attitudes and Subjective Norm in work and private vehicle. See Table 7 and Figure 20 for more details.

Though the findings at Time 2 partially support H2, a number of explanations are possible. Using the advisory ISA and attendance of speed awareness course had no effect on their PBC and reported behaviour relative to baseline levels, but instead created an intention-behavioural gap in their private vehicle. See section 4.4 for literature on this concept.

Table 7: Statistical analysis of the TPB constructs between work and private vehicles and over time.

TIME 1 (N=20)			
Variables	**Median**		**Paired Differences**
	Work	**Private**	
Attitude	4.37	4.19	**z (19) = - 0.748, p = 0. 045, ****
Subjective Norm	4.25	4.00	z (19) = -1.775, p = 0. 076, NS
Perceived Behavioural Control	4.00	3.33	**z (19) = -2.326, p = 0. 020,****
Intention	5.00	5.00	z (19) = -0.447, p = 0. 655, NS
Self-reported Behaviour	4.83	3.44	**z (19) = -3.30 p = 0. 01, ****
TIME 2 (N=20)			
Variables	**Median**		**Paired Differences**
	Work	**Private**	
Attitude	4.25	4.19	z (19) = -0.286, p = 0. 775, NS
Subjective Norm	4.00	4.00	z (19) = 0.157, p = 0. 875, NS
Perceived Behavioural Control	4.16	4.00	**z (19) = -2.532, p= 0.011, ****
Intention	5.00	4.00	**z (19) = -2.232, p= 0.026, ****
Self-reported Behaviour	4.55	3.38	**z (19) = -2.984, p= 0.03, ****

Note: A high median value indicates PBC and Intention in favour of complying with the speed limit
*= Correlation is significant at the 0.01 level (2-tailed) (p <.01)
**= Correlation is significant at the 0.05 level (2-tailed) (p <.05)
NS = Not significant; Bold figures are significant.

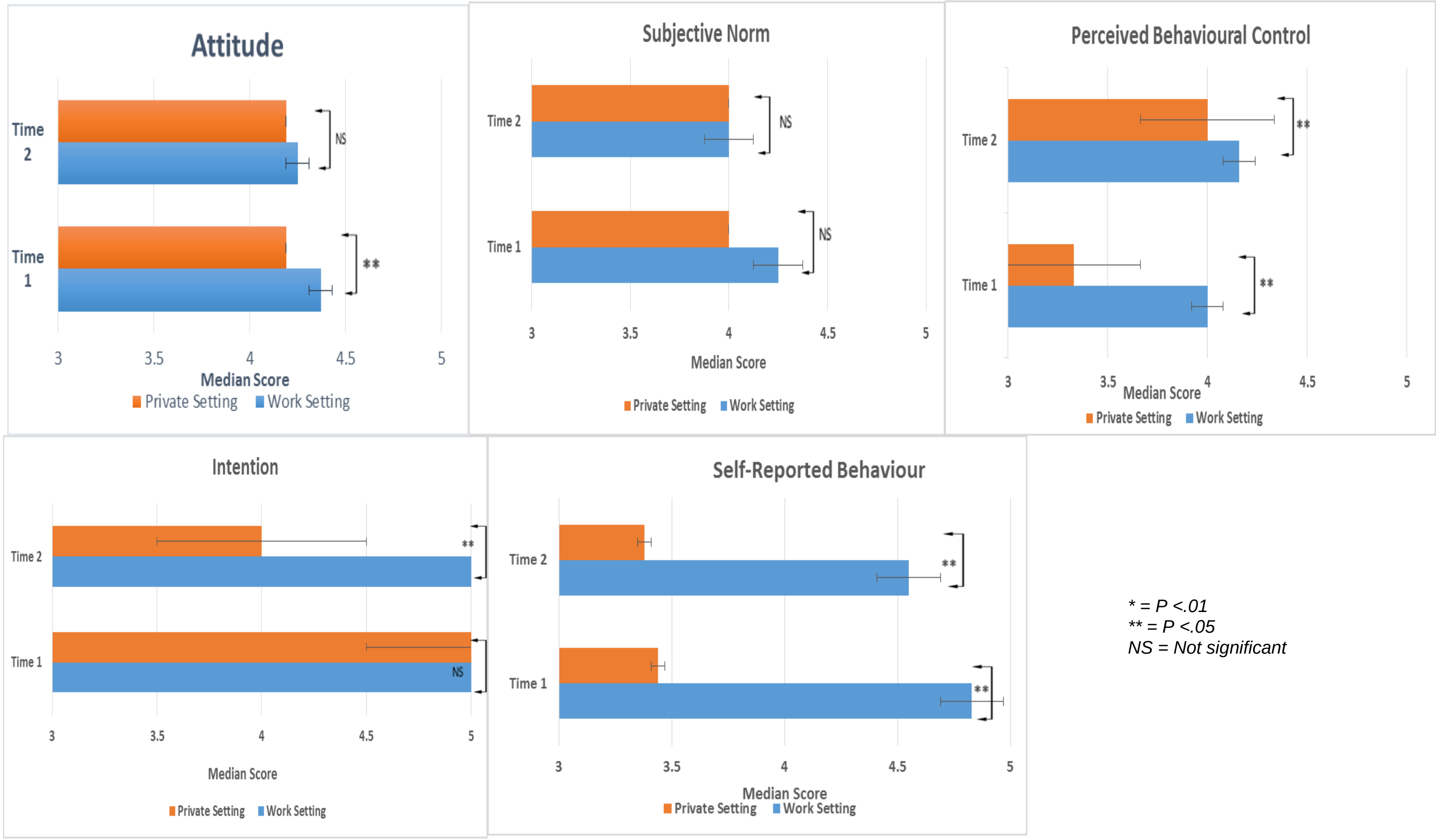

Figure 20: Comparing TPB variables between Setting (Work vs Private) at Time 1 and Time 2.

7.4.3 Testing intervention effect on TPB variables

The effect of the interventions on TPB variables within each setting (i.e. between work vehicles in Time 1 and work vehicles in Time 2; private vehicles in Time 1 and private vehicles in Time 2) was tested using Wilcoxon Signed Rank test. To arrive at this findings, the comparison is done for the 20 drivers who completed all drives in the study. Example, Time 1 work setting data (independent variable) for the 20 participants was compared with their Time 2 work setting data (dependent variable). The same procedure was done for private setting data.

The results revealed no significant effects for the interventions in terms of changing cognitions represented by the TPB constructs. Even though there appeared to be some reductions in participants Attitudes, Subjective Norm, Intention, and Self-reported behaviour scores, the reductions were not statistically significant (See Table 8). It is important to note that their median score remained high on the 5-point Likert scale, indicating that they still had favourable cognitions towards compliance with the speed limit. Therefore, the hypotheses 3 which predicted the interventions will reflect significantly higher TPB constructs relative to the pre-intervention levels within each setting (E.g. work vehicle at Time 1 – work vehicle at Time 2) was not supported. There are several potential reasons for this finding. First, participants' prior information on speeding behaviour might have been a factor leading to the non-significant effects of the interventions. Participants' work in a company where speed violations are taken seriously, and have been exposed to some forms of safety trainings and speed management tools (speed governor), prior to the study. Thus, this was reflected in the high scores of the TPB constructs at baseline. This favourable scores might have produced ceiling effects (Lammers & Badia, 2005), thus masking the potential effect of the interventions. Also, the time interval between both interventions and follow up (two weeks) measurement of the constructs, could have been too short to measure any meaningful changes. The intensity could have been too much thus resulting in diminished return or no effect[8].

Overall, there was no evidence to suggest the interventions effected any changes in the TPB constructs. This is not uncommon, as past studies by Parker et al. (1996), Stead et al. (2005), and Elliot & Armitage (2009b) had similar findings. According to Cook & Flay (1978), the lack of changes of the TPB variables within settings in the present study

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[8] It should be noted that both interventions were delivered approximately within 2 week intervals and could have been too intensive for the participants.

is not unusual given that changes in social cognitions are "notoriously" difficult to achieve (Cook & Flay, 1978). Table 8 and Figure 21 presents details of the results.

Table 8: Testing the effect of the interventions within each settings.

Work Vehicle			
Variables	**Median**		**Paired Differences**
	Time 1	**Time 2**	
Attitude	4.37	4.25	Z (19) = - 0.896, p= 0.370, NS
Subjective Norm	4.25	4.00	Z (19) = -1.223, p= 0.221, NS
Perceived Behavioural Control	4.00	4.16	Z (19) = 0.932, p = 0. 351, NS
Intention	5.00	5.00	Z (19) = -1.069, p = 0. 285, NS
Self-reported Behaviour	4.83	4.55	Z (19) = -1.773, p = 0. 076, NS
Private Vehicle			
Variables	**Median**		**Paired Differences**
	Time 1	**Time 2**	
Attitude	4.37	4.19	Z (19) = - 0.640, p = 0. 522, NS
Subjective Norm	4.00	4.00	Z (19) = 0.499, p = 0. 618, NS
Perceived Behavioural Control	3.33	4.00	Z (19) = 0.858, p = 0. 391, NS
Intention	5.00	4.00	Z (19) = -1.946, p = 0. 052, NS
Self-reported Behaviour	3.44	3.38	Z (19) = 0.967, p = 0. 334, NS

Note: A high median value indicates PBC and Intention in favour of complying with the speed limit
*= Correlation is significant at the 0.01 level (2-tailed) (p<.01)
**= Correlation is significant at the 0.05 level (2-tailed) (p <.05)
NS = Not significant; Bold figures are significant.

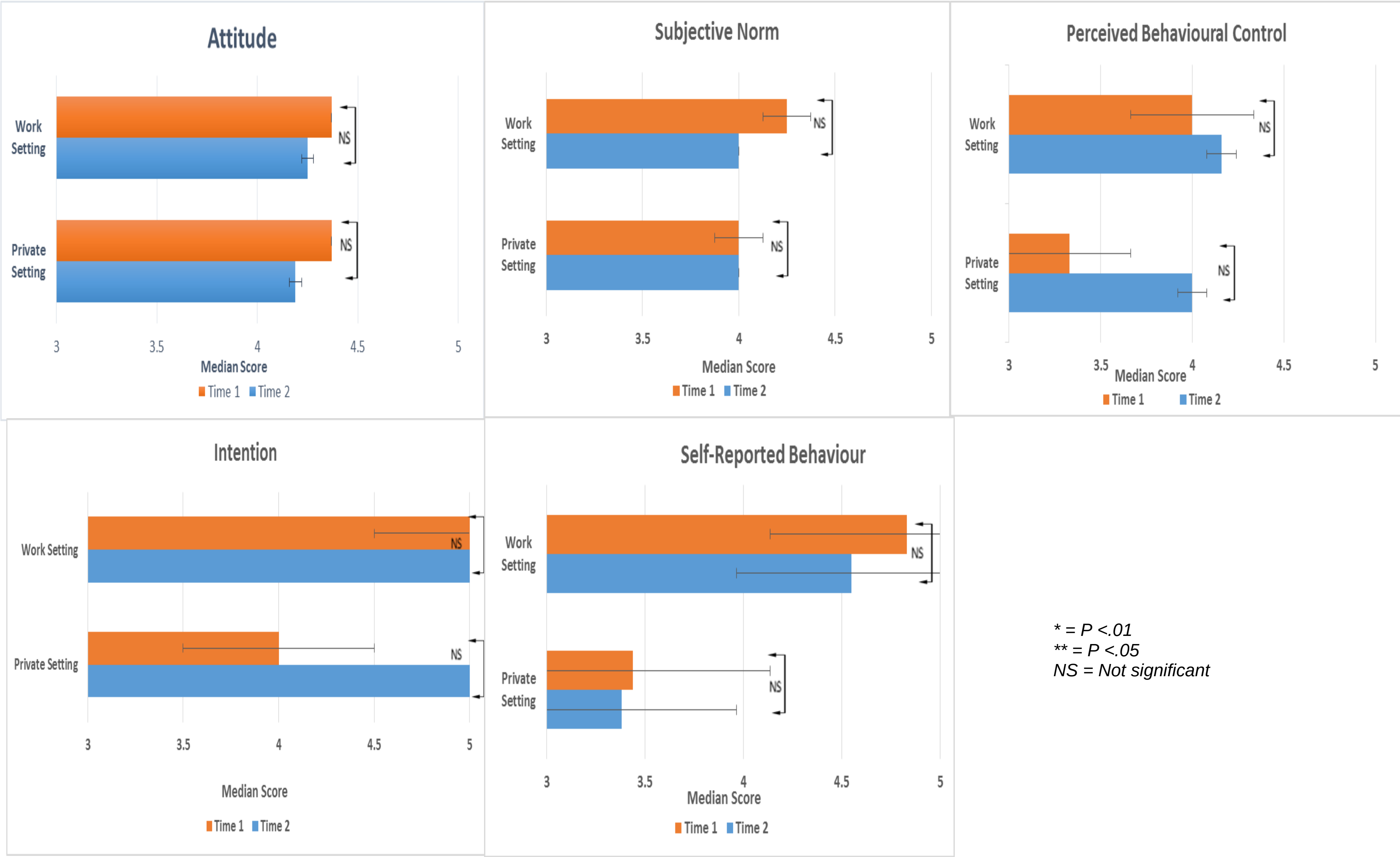

Figure 21: Comparing the TPB constructs within each setting before and after the intervention

7.4.4 Comparing TPB constructs between study drivers' and other Shell drivers

Only 20 out of the 68 participants who completed the questionnaires at Time 1 volunteered in the interventions and completed the questionnaire at Time 2. This reduction in number of participants was primarily due to financial limitation of the study and also low number of drivers' owning private cars.

A Mann-Whitney U-test (which is the non-parametric equivalent to independent-samples t-test) was used to example group differences. Results showed that the 20 test drivers' (who had participated in the interventions and completed all two questionnaires) did not differ from the other 48 participants (who only completed the survey at Time 1) as far as age, working experience with current employer, licence ownership and Mileage was concerned.

Also, A Mann-Whitney U-test was run to determine if there were any differences in the TPB constructs across both set of participants. Volunteers did not differ from non-volunteers on items of the TPB except in their Subjective Norms in work vehicles.

Analysis showed that they only significantly differed in their Subjective Norm in both work and private vehicles ($U=291.5$, $z= -2.597$, $p=0.010$ $p<0.05$), ($U=314$, $z= -2.267$, $p=0.023$ $p<0.05$) respectively. The medians showed that volunteers had more support from important others to comply with speed limit in both their work and private vehicle than non-volunteers (Mdn work vehicles =4.25/4.0; Mdn private vehicles = 4.0/3.5). However, a general tendencies of volunteers to be a little more positive towards speed limit compliance, control and motivation to safety can be noticed.

7.4.5 The relationship between TPB variables and objectively measured speeding behaviour in private settings

According to the Theory of Planned Behaviour, drivers' Intention and Perceived Behavioural Control are the sole determinants of their speed choice (Ajzen & Fishbein, 1980). These relationships have been tested in past studies mostly using self-reported speeding behaviour (Elliot et al., 2004; Stead. 2005), with findings demonstrating the ability of the TPB variables to predict self-reported behaviour. In the current study, section 7.4.1 shows similar results suggesting significant prediction of drivers' self-reported behaviour by their Intention and Perceived Behavioural Control in a private vehicle at Time 1. However, due to data insufficiency, this relationship could not be tested at Time 2.

This section seeks to examine the association between objectively measured speeding behaviour obtained by means of GPS logged data from on-road driving, and TPB variables (obtained from the self-reported questionnaire) in their private vehicle (driver's speeding behaviour was not objectively measured in their fleet setting).

In an attempt to select a measure that is closely matched to the TPB measures, the speeding behaviour is defined as the percentage distance spent driving at 1km/h or more above the speed limit (PDAS) in the 50km/h speed zone. The choice of the 50km/h zone is based on the fact that it was used in the hypothetical driving scenario in the questionnaire.

The comparison is only for the baseline period as the TPB variables were not collected after each of the interventions, but rather after both interventions have been carried out. Thus, the TPB variables or any changes cannot be specifically associated to the objectively measured behaviour for either the ISA or the SAC interventions. Also, there were no significant differences in TPB variables within the settings after the interventions (see section 7.4.3).

Ideally, the relationship between the TPB variables and the objectively measured speeding behaviour would be done using a regression analysis as done in past studies (Conner et al., 2007; Elliot et al., 2007). However, due to the small sample size used in this study, a regression cannot be carried out. Instead, a median split of the TPB variables was performed in order to create a dichotomous variable to compare differences in TPB constructs with the dependent variable being the percentage distance travelled at 1km/h or more above the speed limit. A Mann-Whitney U-test (which is the non-parametric equivalent to independent-samples t-test) was used to examine group differences.

Using the SPSS *transform variable function*, participants were recoded into two categories on the basis of a roughly median split of their TPB variables. The scale *0* (below median) representing low Intention, low PBC, negative Attitudes, and poor Subjective Norm, and *1* (above median) representing high Intention, high PBC, positive Attitudes, and strong Subjective Norm.

Spearman correlation was used to examine associations between objectively measured speeding behaviour and TPB constructs. Table 9 shows that drivers demonstrated high levels of Intention, Attitudes and Subjective Norm with regards to speed choice, however, their PBC levels were just slightly favourable. The median percentage distance travelled at 1km/h or more above the speed limit was 65.1%. The correlations between TPB variables and objectively measured behaviour were generally medium.

Overall, Intentions (r= -0.655, p=0.002) and PBC (r=-0.495, p=0.026) showed the strongest and only statistically significant correlations with objectively measured behaviour. The negative correlations indicate that higher levels of TPB variables (i.e. positive Intentions toward speed limit compliance and strong Perceived Behavioural Control) are correlated with lower levels of objectively measured speeding behaviour (i.e. less compliance with the speed limit).

Table 9: Median, Standard Deviation and Correlation Coefficients of TPB variables with objectively measured speeding behaviour (Period=Baseline; Speed Zone= 50km/h; Setting= Private, N= 20)

S/N	**Variable**	**Median**	**SD**	**PDAS (%)**
1	Intention	5.0	0.7	**-0.655***
2	PBC	3.33	0.9	**-0.495***
3	Attitudes	4.37	0.6	-0.368
4	Subjective Norm	4.0	4	-0.258
5	PDAS (%)	65.1	7.9	1.0

Note: A high median value indicates PBC and Intention in favour of complying with the speed limit
*= Correlation is significant at the 0.01 level (2-tailed) (p <.01)
**= Correlation is significant at the 0.05 level (2-tailed) (p <.05)
NS = Not significant

Table 10 presents results from a Mann-Whitney U test used to determine if there were differences in percentage distance travelled at 1km/h or more above the speed limit (PDAS) between the following types of drivers;

a. Low and high Intenders complying with the speed limit
b. Weak and strong Perceived Behavioural Control
c. Less and more positive Attitudes
d. Weak and strong support from significant other

Table 10: Difference in percentage distance travelled at 1km/h or more above the speed limit (PDAS) on 50km/h speed zone at baseline according to median split of TPB variables

	Intention					
	Low Intention (N=7)		**High Intention** (N=13)		**Median Diff**	**Paired Differences**
	Median	**SD**	**Median**	**SD**		
PDAS (%)	70.9	4.6	62.3	7.9	8.58	U = 10, z =-2.813, p= 0.003, **
	PBC					
	Weak PBC (N= 6)		**Strong PBC** (N=14)		**Median Diff**	**Paired Differences**
	Median	**SD**	**Median**	**SD**		
PDAS (%)	70.1	5.4	62.6	8.1	7.5	U = 19, z =-1.897, p= 0.062, NS
	Attitudes					
	Less Positive Attitudes		**More Positive Attitudes**		**Median Diff**	**Paired Differences**

	(N= 8)		(N= 12)			
	Median	SD	Median	SD		
PDAS (%)	68.3	10.4	62.6	6.2	5.7	U = 32, z =-1.234, p= 0.238, NS
Subjective Norm						
	Weak SN (N= 8)		**Strong SN** (N=12)		**Median Diff**	**Paired Differences**
	Median	SD	Median	SD		
PDAS (%)	69.3	9.6	62.6	6.9	6.7	U = 33, z =-1.157, p= 0.270, NS

Note: A high median value indicates PBC and Intention in favour of complying with the speed limit
*= Correlation is significant at the 0.01 level (2-tailed) (p <.01)
**= Correlation is significant at the 0.05 level (2-tailed) (p <.05)
NS = Not significant

The findings showed that median PDAS was statistically significantly higher for low Intenders (70.8%) than for high Intenders (62.3%), U=10, z=-2.813, p=0.003*.* This suggests that, even though participants generally showed a high Intention to comply with speed limits, there exist differences among them.

However, there was no other statistically significant effect on median PDAS for the other TPB variables analysed, which were potentially meaningful.

Consistent with hypothesis 4, the TPB variables showed medium correlations with objectively measured speeding behaviour.

The negative correlation of Intention and observed speeding behaviour may be related to the concept of *"intention-behaviour gap*" which according to Elliot & Armitage (2009) relates to the gap between what drivers intend to do, and what they actually do. Sheeran (2002), postulates that the gap is caused by two groups; "Inclined Abstainers" (example drivers' with positive intention but who fail to act), and "Disinclined Actors" (example drivers' who comply with speed limits despite their negative intention to do so). The participants in this study may fit into the former, as they held positive intentions which were not translated into behaviour as seen in their high percentage distance travelled at 1km/h or more above the speed limit in their private vehicles. Elliot et al. (2003), conclude that the reason why positive intention of most drivers' to speed limit compliance is not always translated to the target behaviour is that speeding is habitual, and habits tend to interfere with the process of translating motivation to action. This is supported by Musselwhite et al. (2010) who argue that regardless of whether a person intends to drive in a safe manner or does not intend to, habitual processes (automatic or mindless processes developed out of frequent experience with the environment and occur without fore thoughts or conscious information processing) tend to supersede cognitive processing (systematic appraisal of information before acting).

PBC showed a significant negative correlation with observed behaviour, but no significant differences between drivers with weak and strong perceived control of their speed choice. Though not significant, the size of the p values = 0.062 shows the finding may be meaningful.

Though with a very small sample size, the findings of negative correlations patterns of Intention and PBC to observed behaviour used in this study may suggest some external validity for self-reported TPB variables. This finding can help overcome some of the criticism of self-reported measures.

Finally, it is not surprising that driver's Attitudes and Subjective Norm did not have any statistical significance in terms of either correlations or differences between the dichotomous groups with the objectively measured speeding behaviour. According to the TPB, both variables can only predict behaviour through Intention and not directly.

7.5 Conclusions

The current study has provided more support for the TPB as a framework for explaining driving behaviour, and particularly speed limit compliance among drivers' who work in fleet companies with strong safety culture. Currently only one study has theoretically-based it investigation on speed limit compliance by fleet drivers in both work and private setting (Newnam et al., 2004).The existing studies tend to focus more on speed limit compliance by the general population drivers; Elliott et al. (2004); Stead et al., (2005) and rarely test the efficacy of interventions. Study 2, provides an important contribution to road safety related literature and to speed limit compliance related literature specifically by demonstrating the applicability of the TPB in explaining drivers' intention to comply and self-reported behaviour in both work and private settings. Though the TPB model was not only used to provide outcome measures against which to track the effectiveness of the interventions, it was used as the framework for the design of the speed awareness intervention. The study was able to identify participant's Attitudes towards speed limits compliance as the main predictor of Intentions in both work and private vehicles and hence can be used as a tool in developing future interventions in this context.

Findings revealed that the model was better at predicting intentions in private than work vehicles. This finding is consistent with the only other study that has use the TPB in this context, but with Australian fleet drivers (Newnam et al., 2004). According to Newnam et al. (2004), it is quite possible that the TPB was better operationalised in the private-setting than in a work setting, which can be further explained with the adaptation of the

TPB measures from past studies examining general driving, therefore increasing its utility in prediction in the private vehicles. The results also suggest that there is more degree of freedom for people in their private driving than in work driving, as in the former there is not anticipated fear of losing their jobs. Thus, it is very likely for a driver to have negative Attitudes that cannot be expressed in a work vehicle, as there is more control in this setting than in the private driving. In summary, anecdotal evidence will suggest that companies with strong safety culture keep a lid on drivers' expressing their true attitudes even if they might have them.

The results suggest that though drivers' who work in a company with strong safety cultures might have favourable cognitions towards speed limit compliance in both work and private settings, there exist a significant difference between the two; with drivers' being more favourable in their work vehicles. If anything, it may appear that drivers' in this study drive safer in their work than in private vehicles, but it is difficult to adequately take into account differences in mileage, vehicle types, and road types when making this comparison. Nonetheless, this suggests that driving in a company with strong safety culture does not automatically change held beliefs and habits, but only suppress them when at work with driver's being free to express this beliefs and habits in non-work settings. Clearly, this is an important distinction to understand because these elevated propensities for risk-taking in private settings suggest very different intervention strategies in a non-work setting.

Although the interventions did not elicit any significant changes in the participant's TPB constructs, there was no negative-carryover effect as the variables remained the same within each setting.

The study was able to examine the relationship between drivers' objectively measured speeding behaviour in their private vehicles and their TPB variables. Although the sample size of the data was not sufficient in the prediction of the relationship using the logistical model, correlation analyses suggested that drivers' Intention and PBC were negatively associated with their observed behaviour. Also, the median split of the TPB variables revealed that low Intenders were more likely to engage in speed limit violation compared to high Intenders.

Though small in size, the sample for the study appears to reflect the underlying fleet driver's population with regards to working in a company with strong safety culture and ownership of a private car in Nigeria. Drivers' in this study on average were similar to sample used by other work related studies, aged approximately between 40 – 55, (Newnam et al., 2004 ; Poulter et al., 2008), licence ownership estimated to be around

15 – 20 years approximate mileage between 15,000-20000 kilometres per year (Newnam et al., 2004). It is therefore important to treat these results with some level of caution as it is not possible to generalise the findings to the wider population of drivers who work for fleet companies with strong safety culture and own private cars.

Overall, results from the study provides support for the theoretical framework and may inform not only intervention strategies for this set of sampled drivers' but also serve as framework for safety management policies.

7.6 Limitations of study and future studies

Despite the strength of the current study, some methodological aspect of the study require careful consideration. Firstly, the data for this study were based solely on self-reported measures of drivers' who work in a company with strong and active safety culture and rely on driving for their livelihood. Therefore, there is the possibility that participants may have provided socially biased responses (Lajunen & Summala, 2003) which is possible given the behaviour under consideration and how socially and professionally approved it is (Speed limit compliance is an issue of social concern and importance at their work place). However, completion of the questionnaire was done anonymously with participants having nothing to gain giving biased responses.

Also the majority of drivers were within an older age group with a lot of driving experience and married, hence less likely to engage in risky driving behaviour such as speeding (Newnam et al., 2002; Adams-Guppy & Guppy, 1995).

There were typographic errors in section 1 and 5 of the questionnaire. In section 1, question 5 and 6 option of "16-20 years" was mistakenly written as "12-20 years". While in section 5 "Driving your private vehicle". Participants were instructed to evoke a mental picture of driving in their private vehicles down a 50km/hr in the first two instructions blocks; however the third block, which details how they agree and disagree with the statements, mistakenly referred to driving in their work vehicle. Whilst this could possibly have had an influence on participants' responses, the overall findings suggest otherwise since there were significant differences observed between the self-reported work and private driving variables.

Participants were sampled only from within Shell Petroleum Development Company Nigeria and, thus the results may not readily generalisable to the sample population and also general population. Further research should involve drivers' in organisations that do not emphasize strong safety culture.

Chapter 8: Modifying driver speeding behaviour (Study 3)

8.1 Overview

Study 3 presented in this chapter provides results from on-road field trials examining the short-term effectiveness of an advisory Intelligent Speed Assistant (ISA) system and a Speed Awareness Course (SAC) as a means of modifying drivers' speeding behaviour. The study seeks to extend previous research on advisory ISA, and in the evaluation of educational campaigns using objectively measured behaviour.

The main aim of this research programme was to understand and develop an effective speeding intervention for fleet drivers' in their private vehicles. Study 1 elicited the salient beliefs the drivers' held towards speeding and speed limit compliance. In study 2, using the Theory of Planned Behaviour (TPB), drivers' cognitive variables towards the behaviour were examined before and after the interventions. The results showed that, although the drivers had favourable cognition towards the speed limit compliance, their cognitions significantly differed in their work and private settings. The results also noted some significant changes after interaction with the interventions. Whilst the effect of the interventions were promising in attitudinal changes, there are subject to self-report bias, hence the need to objectively measure and evaluate the impacts of the speeding countermeasures on the behaviour.

The following research question will be examined in this chapter.

RQ 5. To what extent will the interventions affect drivers' choice of speed?

8.2 Methods

8.2.1 Participants

Participants were selected based on the following criteria: (1) possession of a driving licence, (2) drove a work vehicle for a fleet company with strong safety culture weekly, (3) drove a private vehicle weekly, (4) had no prior experience with a speed warning system in their private vehicle, (5) had not been involved in any speed awareness course in the 6 months prior to the study.

A total of twenty all-male participants were involved in the study. The age range was between 35- 60 years, and with an average annual mileage of about 10,000 kilometre.

8.2.2 Procedure

The study was done in Nigeria between the 5th of November 2016 and 26th of February 2017. It involved a within group design experimental study. Participants performed three drives in total (baseline drive, speed warning assistance drive and speed awareness course drive) in real traffic conditions, and along a test route of 46km. The test route is a major dual carriage road linking the city of Port Harcourt to the airport in Omagwa, a growing sub-urban area in River State Nigeria (See Figure 22). The test route was circular and had the following features; varying speed limits of 50, 60 and 80 km/h, urban roads with mixed traffic, a moderate number of pedestrians, rural highway sections, and dual-carriageways. Overall, there were 9-speed limit change points on the test route.

The initial choice of this route was based on the suggestion of the Federal Road Safety Corps (the agency responsible for road traffic safety in Nigeria), and was hinged on the following factors: (1) free flowing traffic conditions (2) availability of different speed limit zones and signage (3) known route with high traffic crashes and fatalities. A speed survey using a radar gun was carried out to investigate the speed profile of the route with results suggesting moderate speed limit violation by motorist.

The route was aggregated into 10 different segments with a new segment defined every time there was a change in speed limit. Each record in the segment dataset contains the total distance of the segment, number of observation included in the segment and the time taken to cover the segment. Sample speed profile of the route and details of each speed zone segment can be seen in Figure 22 and Figure 23 respectively. A description of the segments can be seen in Table 11.

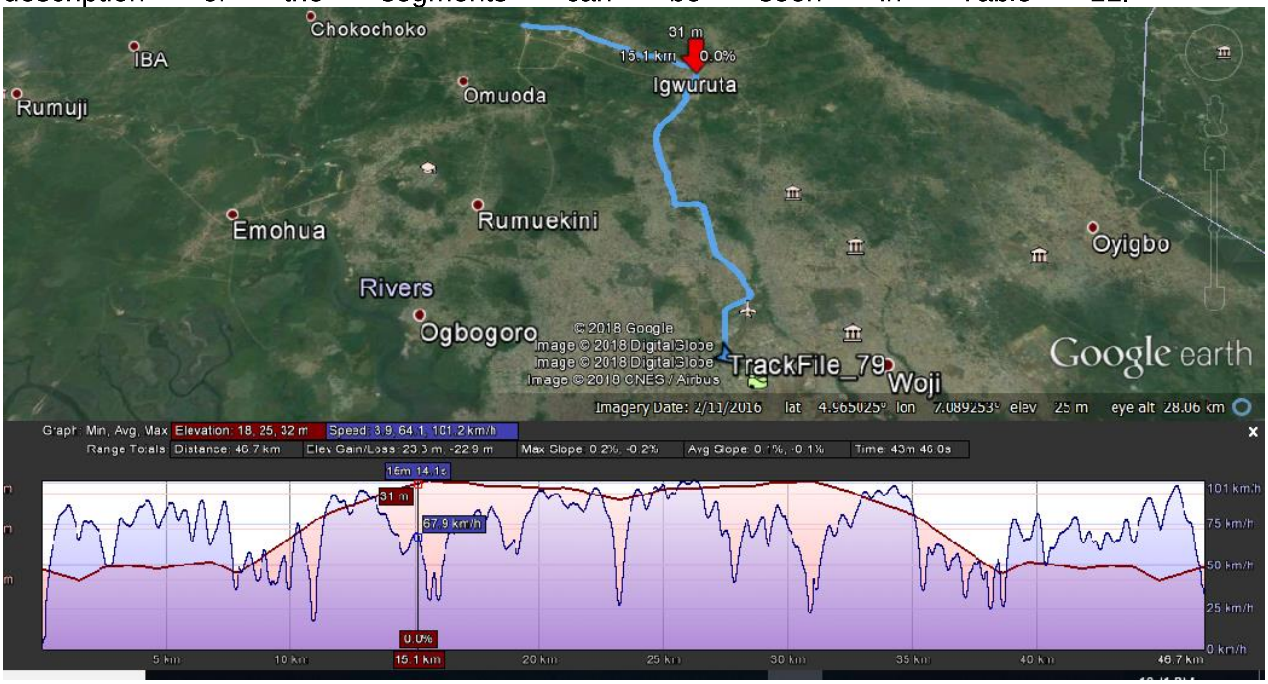

Figure 22: Sample Speed Profile for test route.

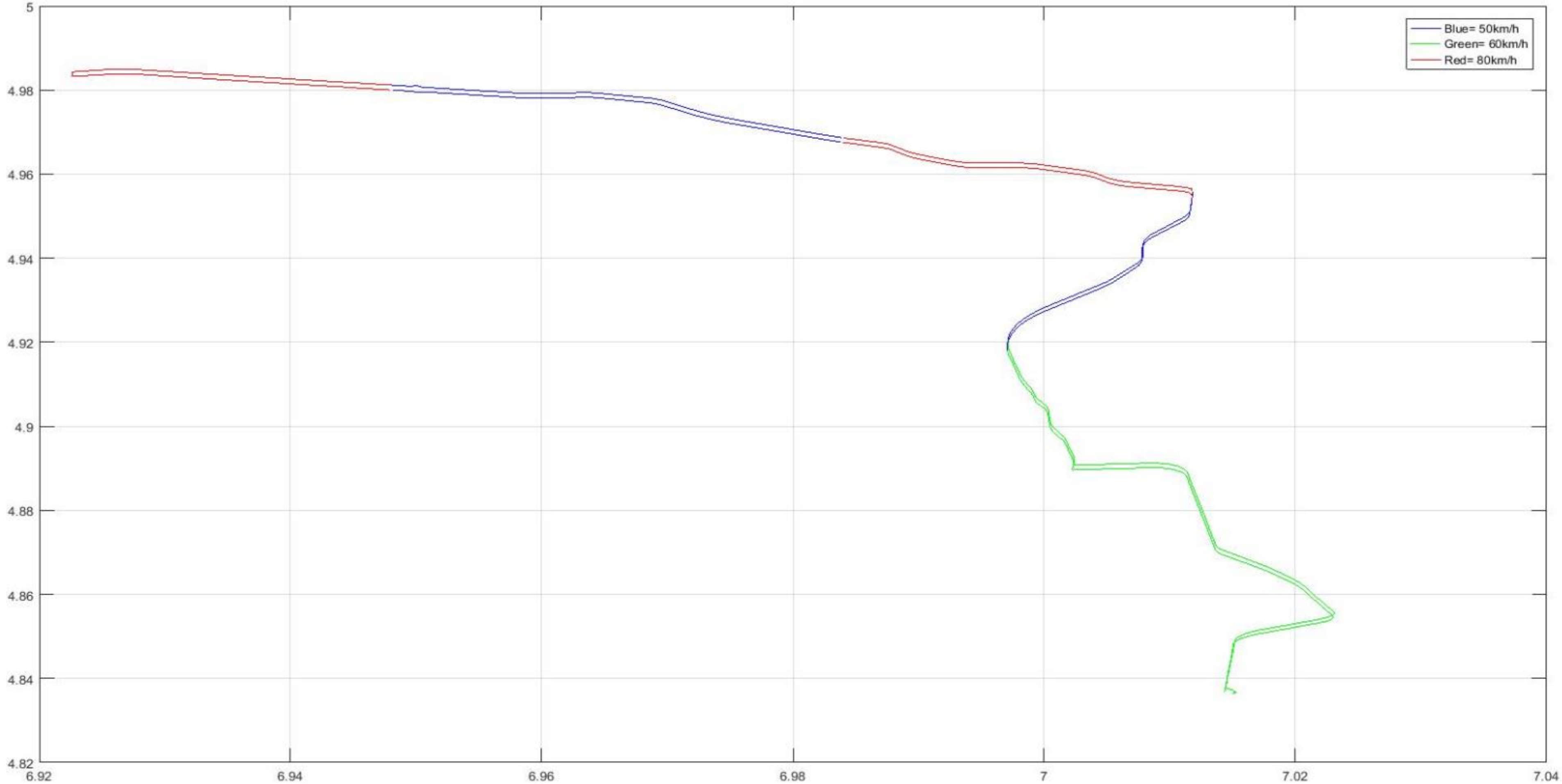

Figure 23: Test route and a description of the speed limit zones.

Table 11: Description of the different speed zones on the test route

Segment	Description	Length (Km)	Speed Limit (Km/h)	% Distance Driven
1	Eliozu Road (To)	7.64	60	16.5
2	Rukpokwu Built (To)	3.27	50	7.1
3	Rukpokwu Express(To)	3.75	80	8.2
4	Iguruta Built (To)	5.10	50	11.1
5	Airport Road (To)	3.27	80	7.1
6	Airport Road (Fro)	3.27	80	7.1
7	Iguruta Built (Fro)	5.10	50	11.1
8	Rukpokwu Express(Fro)	3.72	80	8.1
9	Rukpokwu Built (Fro)	3.35	50	7.23
10	Eliozu Road (Fro)	7.64	60	16.5
	Total	**46.31**		**100**

Figure 24 compares the proportion of distance driven among the different speed limit zones across the test route and suggest that the distance driven was evenly distributed with data collected.

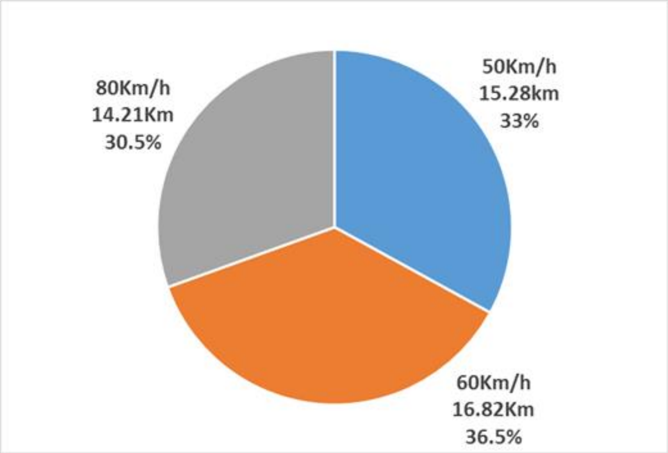

Figure 24: Distribution of total vehicle kilometres with respect to speed zones

The participants' behaviour was registered by 204,000 GPS position in total over a cumulative distance of about 2800 kilometres of driving in approximately 75 hours (corresponds to approximately 50 minutes of driving per participant per phase). For the purpose of the study a rented automatic Toyota Camry, 1999 model was used for all the drives.

The first phase of the experiment began with the baseline drives on the 5th of November 2016 and ended on the 18th of December 2016. The baseline was to reflect drivers' normal driving behaviour. During the baseline drives, participants were asked to drive as they would normally drive in their private vehicles, this was without any intervention, and they were also not aware that their driving behaviour was being logged with the GPS device. After the baseline period, the drivers' were randomly divided in to two groups which was to counterbalance the different interventions. 24 participants were involved in the baseline drives.

The second phase of the study began on the 7th of January 2017 with Group 1 beginning with the advisory ISA intervention. Participants drove with a smartphone attached to the dashboard of the car. The phone had the ISA application installed, and provided participants speed limits information and warnings. (See description of the application in section 8.2.3.2). During these drives, drivers' behaviour was logged with the GPS logger.

Group 2 on the other hand, had a speed awareness course that took place on the 14th of January. The training session lasted for 2 hours in a booked hotel mini conference room. During the sessions, participants had printed materials of the course and were involved in a presentation and discussions led by the Ph.D. candidate (see description of the course in section 8.2.3.1). They began their drive session immediately after the training, which took place within a week of completion of the course.

The third phase of the study involved counterbalancing of the interventions between the groups. Group 1 had the speed awareness course on the 28th of January and subsequent drives till 4th of February. Group 2 on the other drove with the advisory ISA between 11th of February to 26th of February. A total of 20 drivers were able to complete all 3 experimental drives out of the initial 24 drivers that drove at baseline.

On completing the final drive, participants were debriefed and paid N10,000 (Ten thousand naira only) the equivalent of £20 for their participation in the study.

Data collection and validation process

The following types of equipment were used during the data collection period; personal laptop computer pre-installed with Google Earth Pro and GPS mapping software, and 4 number 1Hz GPS data loggers. Test drives were mostly during weekends (Saturday and Sunday), and from 6 am to 12 noon. However, due to rescheduling, three drives were carried out during the weekday of Monday (all done before the morning peak period). The choice of weekend drives was due to the fact that participants were mostly at work during weekdays, and traffic levels were lower at weekends.

The drives began with the Ph.D. candidate giving participants information about the test route, and instructions on how to use the advisory speed warning application (in cases of ISA drives). Participants were asked to drive as they would normally in their day-today private (non-work) driving. The drives were done without an observer or experimenter in the car to minimise “observer effects”[9]. According to Spano (2006), the presence of a researcher could possibly influence the behaviour of the participants by serving as an intervention. Like most on-road studies it was not possible to control for all factors and circumstances, thus, participants were asked to report to the researcher incidences of traffic congestion, adverse weather, road crashes, or any personal factor that could have prevented them from driving normally.

To mitigate against these factors, all data where participants reported incidents affecting their test drives (as stated above) were invalidated, and participants asked to re-test on a different date (if they agreed to). For example, there was an incident were a participant reported road-blockade during baseline drive and was unable to repeat the drive subsequently for personal reasons.

Before each drive, the researcher made sure the GPS device and the advisory speed warning application (for ISA drives) were turned on and functional.

After each drive, the GPS device is connected to the laptop, and with the GPS software the data is downloaded and saved in a folder with participants ID on the secure M-drive of the University of Leeds. Example, Figure 25 shows how ISA drive data for group 1 was saved.

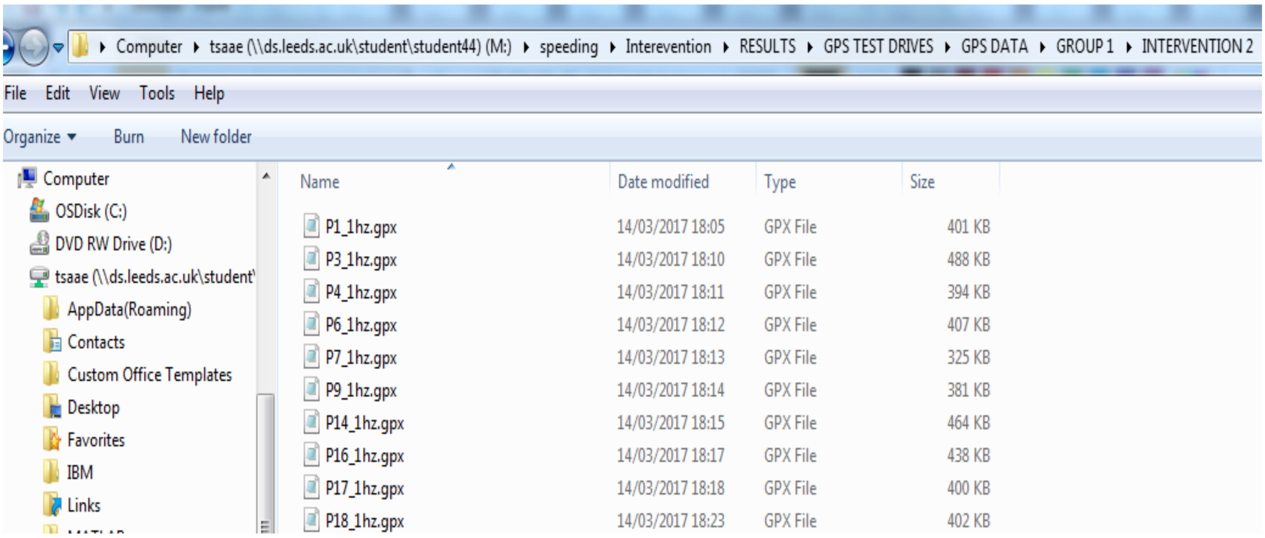

Figure 25: Data saved in University of Leeds M-drive

To check that the drive was done on the test route, the GPS data was plotted on the google Earth pro.

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[9] Observer Effect: A form of reactivity in which subjects modify an aspect of their behaviour, in response to their knowing that they are being studied (Spano, 2006),

8.2.3 Interventions

8.2.3.1 Speed Awareness Course (SAC)

Using the framework of the UK National Speed Awareness Course (NSAC) which was developed in 2007 by a sub-committee of the Association of National Driver Intervention Scheme Providers (ANDISP), an educational intervention was designed to increase drivers' motivation to speed limit compliance. The course was designed with the aim of increasing participant's intention to comply with the speed limits and to drive at an appropriate speed. The aim of the course was to achieve the following objectives:

1. To identify the benefits of complying with speed limits.
2. To raise awareness of appropriate attitudes towards the misuse of speed.
3. To increase understanding of the consequences of speeding and to explore the advantages and disadvantages of speeding.
4. To improve participant's knowledge of speed limits and skills in identifying different speed limit areas.
5. To gain recognition of personal responsibility for choice of speed.
6. To provide participants with the opportunity to implement their increased knowledge and skills in hazard perception.

The course was delivered over a duration of two hours, with each group having it on different days. Participants began with an "Ice breaker", designed to elicit participant knowledge of the Highway Code (See appendix A.5). Participants were then presented with two short video clips:

1. "*Save kids' lives*" a film directed by Luc Besson for the Fédération Internationale de l'Automobile (FIA) in 2015, to deliver a potent visual message highlighting the dangers facing children around the world in their journey to school whether caused by lack of infrastructure in developing nations or by heavy traffic in developed nations.
2. "Classroom" a 2014 Department of Environment Northern Ireland (DOENI), road safety campaign video. The film depicts graphic scene of school children seen happily going on a picnic to enjoy their day. In the middle of the field trip, a car speeds out of control and pummels the kids to death. This is followed by a voiceover, "Since 2000, speeding has killed a classroom of our children. Shame on you. You can never control the consequences if you speed."

Since it was beyond the scope (time and cost implications) of this study to design videos that target drivers' cognitive processes, several previous speed limit compliance and road safety campaigns videos were watched to see those that are related to the research aim and context. Example of such videos include the Scottish Road Safety Foolsspeed campaign (1999-2001) videos. Although, the videos targeted the core variables of interest in the study, they were unlikely to engage the drivers' with the subject of speed limit compliance. Considering the differences in culture and context, the participants in the study would not have been able to relate with the videos. The "*Save kids' lives*" and "Classroom" videos were selected as they presented a platform in which the sampled participants could easily relate and engage with. They both touch on the dangers facing millions of children's lives on the roads around the world and could serve as a stimuli for thoughts and discussions. Although, they have been criticism of the graphic nature of the videos, dramatic construction and presentation as a format has been used in past studies for attitudinal changes with relative success achieved (O'Brien et al., 2002). On the contrary, Elliott (2003) and Shanahan et al. (2000) suggest the avoidance of threat appeals or to use them with great caution in behavioural interventions. Elliott, (2003) further argues that such appeals may be too risky and complicated. In their review of the effectiveness of arousing threat appeals in road safety interventions, Lewis et al. (2007) concluded that the use of threat appeals remains contentious among road safety practitioners, however, they recommend that if they must be used, it should be done after thorough examination of the messages among the target audience, and ensure it elicits high levels of efficacy and vulnerability.

The efficacy of using videos in educational training has been justified by social-cognitive concept of "Modelling" and "Learning-by-doing" (Giannini et al., 2013), which according to Bandura et al. (1963) "show the activation of a complex set of perceptual, attentional, and memory processes that lead to the internalisation of the reference models". Dewey (1938) adds that learning through experience can be facilitated by personal involvement and active participation respectively.

The aim of the videos used in the current study was to serve as "icebreakers", and help participants begin the course by activating their emotions and cognitions with respect to road traffic safety. Fylan et al. (2006) in a review of speeding interventions, proposed that educational speeding intervention should be designed in such a way as to promote elaboration (e.g. group discussions).

A TPB-based presentation, and discussions targeting **Behavioural Beliefs** (causes of speeding, consequences of speed limit violations, advantages of speed limit compliance), **Normative Beliefs** (what family members, employers, Police and friends think of speeding), and **Control Beliefs** (Strategies to help drivers avoid speeding in times of rush, poor knowledge of speed limits and when driving in good roads), was delivered. The course concluded with participants completing Implementation Intentions sheets which are “IF-THEN” strategies that help individuals translate their Motivation (goal intention) into Action (behaviour) (See appendix A.6). Refer to Chapter 4 for discussions. Participants received certificate of attendance for the training.

Speed Awareness Course Presentation

Certificate of Attendance Presentation

Figure 26: Speed awareness course session with participants

The speed awareness course used in the current study was modelled after the UK National Speed Awareness Course (NSAC), however, it was different from the NSAC in content, structure, and delivery. As part of the development of the course, the Ph.D. candidate was opportune to meet and discuss with one of the advisors for the NSAC. Whilst the advisor was very helpful in the provision of theoretical background, due to copyright protection no material was provided or can be re-used. The structure, contents, and delivery for the current study were designed by the candidate based on available literature.[10]

8.2.3.2 Intelligent Speed Assistance (ISA)

The system is a GPS based smartphone application, which is designed and developed by Sygic Business Solutions and made of two components: (i) road maps and (ii) a navigation unit with a digital map containing speed limits within the test route. The application, when turned on, continuously identifies the position of the vehicle, calculates the speed, and compares with a digital map to determine the speed limit at that position. The Human Machine Interface (HMI) for the system, employed a visual display on the

[10] The name of the course “Speed Awareness Course ” used in this study should not be confused with the “National Speed Awareness Course” used in the UK. The choice of name is only for the purpose clarity and used only for this research, and therefor would not be used for any public presentation.

phone screen showing the current speed limit, the vehicle speed, and a digital map. The application also provides continuous warning (beeping alert or voice alert) when the vehicle speed exceeds the legal speed limit. The application worked in a way that whenever the speed limit was exceeded, the colour of the vehicle's current speed background changed from black (complying with speed limit) to red (warning that the speed limit is exceeded). See Figure 27 for a description. The driver repeatedly received the warnings until the vehicle speed returned to below the recommended speed limit. However, it was still possible for the driver to accelerate. The system speed did not necessarily correspond to the speeds shown on the vehicle's speedometer. This was because most cars are manufactured with speedometers showing speed margins that are somewhat higher than the vehicle's actual speed (Warner & Aberg, 2008). The speedometer of the test vehicle showed a speeding rate of approximately 5km/h when the speed warning application measured a 1km/h excess in speed.

The participant data was logged using a hand-held 1Hz GPS logger, which was kept on top the dashboard.

When the speed limit has not been exceeded

When the speed limit has been exceeded

GPS Logger

Particicipant getting ready for a drive

Figure 27: Visual alerts of the ISA system, GPS logger and system set up in the vehicle

8.2.4 Behavioural measures

Some studies on drivers' speeding behaviours have described the effect of speeding interventions by observing changes in the drivers' speed at different locations on the test areas such as locations with varying speed limits (Várhelyi et al., 2004). This is often referred to as point speed, and is simply described using average speed and standard deviations of speed. Some conventional descriptions such as, the 85th percentile speed, the percentage of speeds above the speed limit, and number of speed violations have also been used in previous studies (Paatalo et al., 2001). These methods were mostly used in studies that involved the normal cross-sectional speed measurement (point speed) (Lahrmann et al., 2012). However, with second-by-second GPS data providing detailed track of the movement of individual vehicles, the effects of interventions on driver's speed choice can also now be investigated based either as a proportion of the time the vehicles travel on the network (Regan et al., 2006a; Young et al., 2010; Warner & Aberg, 2008) or proportion of the distance travelled by the vehicle between two points (Lahrmann et al., 2012; Lai et al., 2012b; Vlassenroot et al., 2007; Chorlton & Conner, 2012; Agerholm et al., 2008a).

Time-based observations are based on the average speeds at which the vehicle travels per second, meaning all speeds including zero speed (0 km/h) are included in the calculations of average speeds and are quite useful in estimating travel times (Vlassenroot et al., 2007). However, Chorlton & Conner (2012); Lai & Carsten (2012) ; Agerholm et al. (2008a), argue that time- based data, though intuitively valid, can often introduce undue weights to the data stream, especially when vehicle speed is zero or very low (e.g., when vehicles are stopped or moving slowly in congestion). According to Agerholm et al. (2008a) and Agerholm et al. (2008b) time-based data can result in systematic bias, since large exceedance of a speed limit on a given distance will be underestimated, because the higher the speed, the less time will be spent on the distance. Consequently, small violations closer to the speed limit will result in longer time spent, compared with large violations for the same distance.

Alternatively, distance-based observations are calculated based on the average speeds at which people travel per metre. Zero and very low speeds are excluded in the calculations since no distance is covered, resulting in the weighting of higher speed in the calculation of averages. Therefore, any bias towards low speed is avoided (Vlassenroot et al., 2007). Finally, the distance driven has been described as the normal measure of exposure to on-the-road risk (Agerholm, 2011; Elvik et al., 2009). Therefore for this study, results are based on the distance driven above the speed limit rather than time.

8.3 Data analysis

8.3.1 Data cleaning and weighting

All valid data set were added into the SPSS file (excluding the four participants that completed only the baseline drives). However for the purpose of analysis there is need for filtering and smoothing of data in order to remove systematic errors and reduce the effect of random errors, respectively. Agerholm (2011) also argues that the selection of the type of data to analyse affects the amount of effect ISA has on speeding behaviour. For example, considering that it is not possible for drivers' to exceed the speed limit when they are stopped, the addition of points where the vehicle stopped would over-state the extent of speed limit compliance (Ellison & Greaves, 2010). In their study, Paatalo el al. (2001) made a distinction between overall driving speed, and speed without stops (stops being defined as speed below 1km/h). Some studies have used mid-block speed data in their analysis (Hjälmdahl & Várhelyi, 2004; Várhelyi, et al., 2004), as the effect of interventions are expected to be more significant when compared with analysis using complete data as lower speeds and where effect of acceleration below the speed limit are not included (Vlassenroot et al., 2007). Agerholm (2011), argues that although congestions would not confound the results, there is an issue if selected spots results are considered representative of the overall driving behaviour during the entire trial.

According to Lahrmann et al. (2012), only speed observations where the driver speed choice is not limited by a car ahead, a curve, or a signalised intersection, should be included in the analysis. But as GPS log files do not show this kind of observation, the best solution is to exclude speed data from the analysis in cases where it can be reasonably assumed that speed choice is not free (or there is no speed choice) (Regan et al., 2006a). Different threshold, have been used by past studies to identify valuable trips and movement with the threshold varying mainly by the characteristics of the local activities (Gong et al., 2014). For this study, the following threshold were assumed (i) exclusion of speed data below 1km/h (Paatalo el al., 2001) or above 150km/h, and (ii) removal of all data in areas without a valid speed limit (e.g. where the speed limit shown by the application did not correspond to the legal speed limit of the section). Approximately 5% (10, 200) of GPS data point was excluded from analyses.

Considering that the observed data were time-based and relatively heterogeneous, it was necessary to ensure that the analyses were not biased towards speed observations where the driver speed choice is limited by other vehicles ahead or vehicle was stationary. Therefore, the time-based observations, are weighted in proportion to the distance travelled between two observations using the formula below:

$\bar{x} = \sum_{i=1}^{n} \mathrm{vi} * \mathrm{li} / \sum_{i=1}^{n} \mathrm{li}$	V_i= Speed over distance l_i l_i= The distance travelled with the speed vi $\bar{x}$=Weighted speed

Source: Lahrmann et al. (2012)

8.3.2 Statistical analysis

Inspection of the histograms, normality plots, ratios of skewness, and kurtosis to their respective standard errors showed no strong departures from normality as assessed by Shapiro-Wilk's test ($p > .05$) and no extreme univariate outliers, as assessed by inspection of a boxplot on drivers' speed choice. The assumption of Sphericity was met at all phases of the analysis as assessed by Mauchly's test of Sphericity ($p > .05$).

A series of repeated measure One-way Analysis of Variance (ANOVA) were carried out to assess the impacts of the interventions on drivers' choice of speed on the different speed limit zones. The one-way repeated ANOVA is used to determine whether there are any significant differences in drivers' speed choice after undergoing training and use of ISA application compared with their baseline levels.

The analyses were performed separately for the three speed zones (50, 60 and 80 km/h roads) and a significance level of $\alpha = 0.05$ was used to analyse the possible differences among the 3 phases (Baseline, ISA and SAC). Only weighted data were analyzed using Statistical Package for Social Sciences (SPSS).

8.4 Results and discussion

In the following section, the effects of the interventions on drivers' speed choice are examined, discussed and reported. The results are presented under different indicators and compared across the different speed limit zones for both ISA and SAC.

8.4.1 Speed distribution for all speed zones

The cumulative speed distributions of the drivers' are presented for the 50, 60 and 80 km/h speed zones, separately. These analyses examine changes in the speed distribution during the intervention stages compared baseline levels. Figure 28 shows effects of the interventions on participant's speed distributions for 50, 60 and 80 km/h zones, respectively. As revealed, the distribution are all normal-like curves with evidence of a change from baseline and the intervention periods for all speed zones. The curves show participants' speeding was greater under the baseline conditions while a greater proportion of their driving during ISA and SAC periods were below the speed limits.

On the 50km/hr road zone, speed violation under the ISA and SAC systems is observed at higher percentiles, compared with the baseline condition. The speed distribution was largest in this studied section, when compared with other speed zone (these are roads where the drivers' were more likely to encounter conflicts with vulnerable road users, such as pedestrians, and more likely to be congested). There also appear to be a slight increase in the lower speeds during ISA, when compared with SAC speed profiles.

In the 60 km/h road zone, speed limit violation in the ISA and SAC periods were during and above the 85th percentile speed. However, during the baseline drive, speeding began at the 25th percentile speed, making it the speed zone with the highest speeding proportions. The zone also had the smallest speed distribution and largest speed variance in comparison to other speed zones. This could be due to decrease in the highest speed and increase in the lowest speed. The interventions had marginal effect on the lower end (10th percentile speeds) of the speed distribution, representing drivers' whose speed choice was lower than the speed limits.

In the 80km/h road zone, there was almost no speeding in the ISA period, and marginal speeding in both the SAC and Baseline period (in the higher percentiles). The distribution curve moved to the left at both ISA and SAC phases. The movement indicates reductions along the whole speed data, which is reflected by the marginally changed speed variance. Compared with other speed zones, there was a level of minimum speed variability in this zone.

As predicted both the advisory Intelligent Speed Assistant (ISA) application, and the Speed Awareness Course (SAC) showed a distinctive effect in translating the cumulative speed distribution across all the speed zones, when compared with the baseline period. According to Comte (2001) translation is where the shape of the distribution remains the same, but is shifted to either downwards or left-ward in terms of speed. The interventions were able reduce the speed distribution, when compared with baseline levels. Similar to past speed intervention studies (ISA: Hjalmdahl et al., 2002, Lai et al., 2007; Lai et al., 2012b; Regan et al., 2006a; SAC: Hou et al., 2012), the speed at which drivers' drove over the limit, and in particular the high end speeds exceeding the limits were curtailed by both interventions. On the other hand, in line with the results of similar studies of ISA Comte (2001); Albert et al.(2007) and of SAC Hou et al. (2012), the interventions had minimal effect on the lower ends of the distribution, which represent speeds that are lower than the speed limit (Albert et al., 2007). Not only did the interventions reduce maximum speeds, and speed violations, they also did not encourage participants to gain time (from perceived lost time) by attempting to drive closer to the speed limits, i.e. no negative behavioural adaptation was observed. Comparatively, the ISA intervention appear to have produced the lowest speed distribution across the different speed zones.

The findings support H4a and H4b, which proposed that both intervention will significantly reshape the speed distribution.

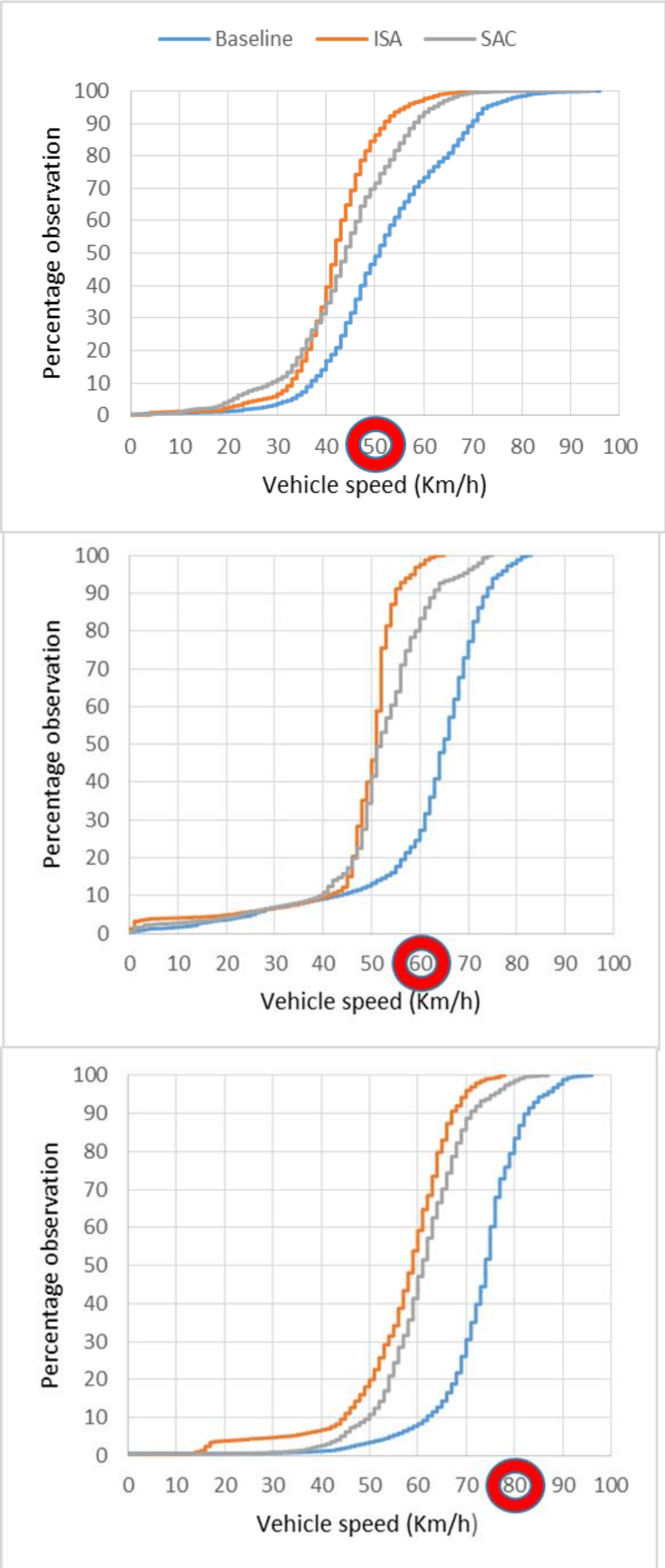


Figure 28: Cumulative speed distribution curves for all speed zones

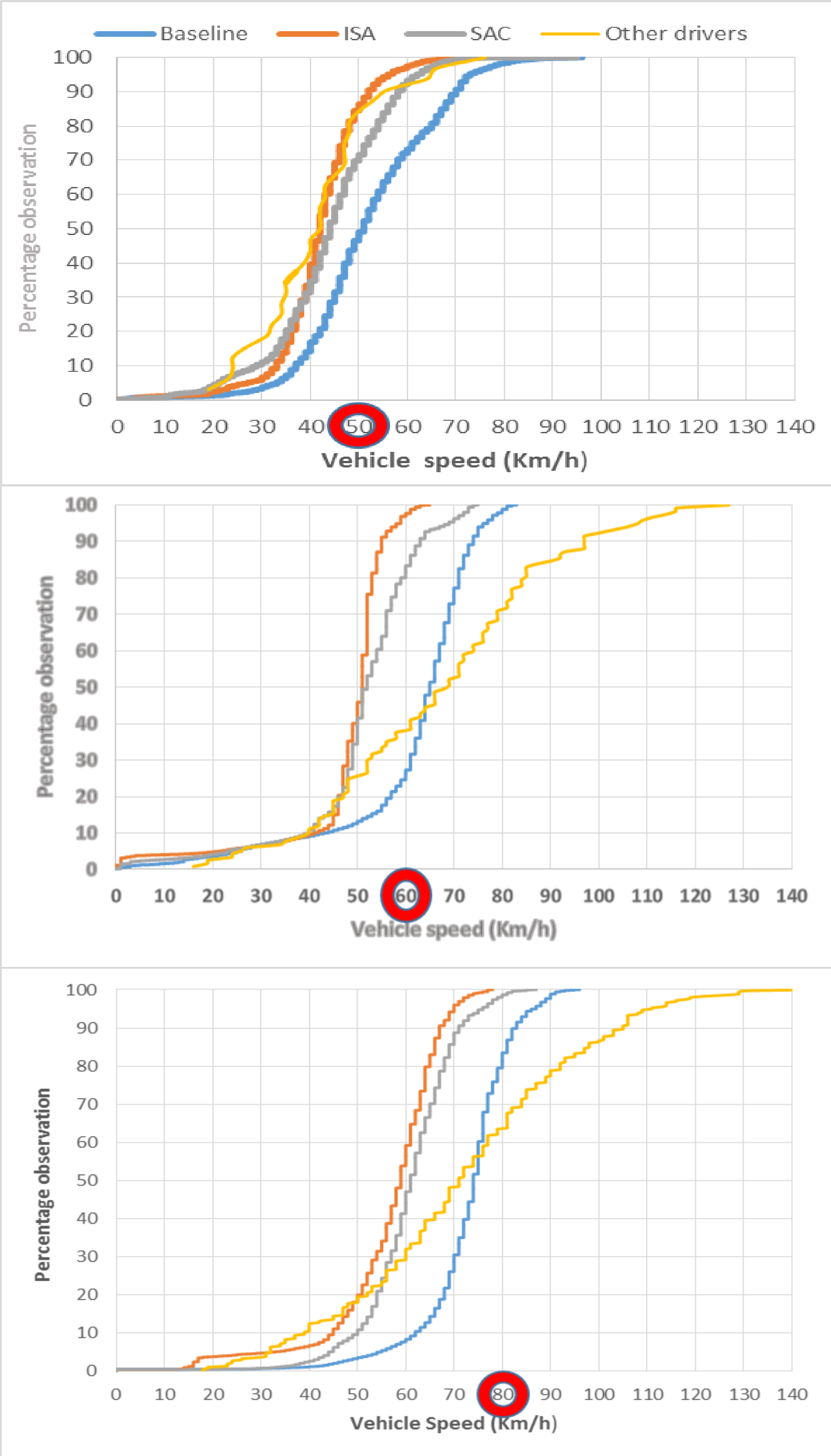


Figure 29: cumulative Speed distribution of test drivers and non-test drivers

8.4.1.1 Comparison of speed distribution with that of other motorists

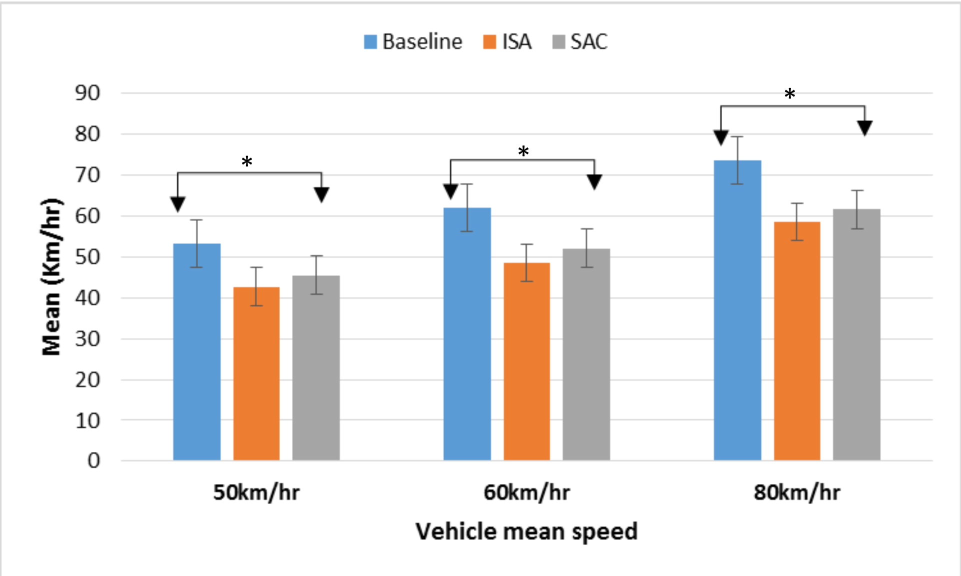
The speed distribution of the test participants (logged using the GPS device before and after the interventions) was compared with that of other motorists (logged during the route selection phase using a radar gun) on the test route. Figure 29 shows that in the 50km/h speed zone, the mean speed and 85th percentile speed of other motorists were lower than those of the test participants relative to their baseline levels, but similar to the ISA and SAC levels. These differences in the 50km/h speed zone during the baseline could be as a result of the different days of data collection. Data for non-study drivers were collected during weekdays as against mostly weekend data collected for the study drivers. This could be related to the fact there is usually more traffic during the weekdays in the 50km/h zone (which is an urban zone with vulnerable road users and have more traffic compared to other speed zones which are rural highways), thus, suggesting the reduced speed choice from non-study drivers compared to the test drivers. It is also possible that the test drivers were more inclined to speeding in urban roads even though they self-report favourable intention to comply with the speed limit. However, in both the 60 and 80km/h roads, other motorist 85th percentile speeds were both higher than those of the test drivers when compared across all stages. On the other hand, the mean speed of both the other motorist and baseline drives of the test drivers' appear to be similar on both 60 and 80km/h roads. This result shows that other motorist drove more at the higher speed distribution than the test drivers. This confirms that the participants in this study may have been slightly conservative with their speed choice, likely because of their work background. However, results and finding should be interpreted with caution due to the differences in data collection techniques (spot speed data for other motorist and GPS data for test drivers), and different days of data collection.

8.4.2 Mean speed

This indicator shows the average speed for driving in a certain period, and usually includes all driving (inclusive of congestion and idling), unless other approaches such as weighting are used to avoid, congestion or idling. The mean speeds were compared across the various speed limit zones, separately for the baseline, ISA and SAC stages, in other to determine if there were any differences in mean driving speeds. At baseline, drivers' travelled at slightly higher speeds than the speed limit in the 50km/h (+3.2km/h) and 60km/h (+2.3km/h) sections of the road, but below the speed limit in the 80km/h zone (-6.4km/h). However, there was a general trend for drivers' to travel under the speed limit in all speed zones across the SAC and ISA periods.

A one-way repeated measures ANOVA was conducted to compare the effects of the interventions on mean speeds. Results showed significant reduction of mean speeds at p<.01 level for both ISA and SAC at all speed zones. **50km/h zone** [F (2, 38) = 75.1, p <.01], **60km/h zone** [F (2, 38) = 41.9, p<.01] and **80km/h zone** [F (2, 38) = 69.8, p<.01]. Post hoc comparisons using the Bonferroni t-test indicated that the mean speed during the ISA intervention (M= 42.7) was only significantly different than the SAC (M= 45.6) intervention at the 50km/h zone. However, the mean speeds during ISA intervention did not significantly differ from those during SAC intervention in the 60 and 80km/h speed zones. See Table 12 and Figure 30 for details.

Taken together, these results suggest that both the advisory Intelligent Speed Assistant System and Speed Awareness Course were effective in reducing mean speed across all speed zones. However, the effectiveness of the ISA system varied across the different speed zones. Statistically significant reductions in mean speeds derived from use of the ISA system tended to be of 10 to 15km/h. On 50km/h roads, mostly urban roads, with a mixture of vulnerable road users and more traffic, the ISA system resulted in a reduction in mean speed of 19.7%.



*** p <.01**; **** = p <.05**, **NS: Not significant**

Figure 30: Mean Speed of participants across all speed zones and phases

On the urban arterial road of 60 km/h, the ISA system reduced the mean speed by 21.6%. On the 80km/h road, with mostly consisting of highways, the system brought the mean speed down by 20.4%.

The mean speed reduction benefits of an advisory ISA has been established in previous studies (Brookhuis & de Waard, 1999; Ghadiri et al., 2013; Lai et al., 2012b; Lahrmann et al., 2012; Regan et al., 2006a; Agerholm et al., 2008a; Warner & Aberg, 2008). These studies have typically found mean speed reductions between 1 and 5km/h, depending on the road type. The measure has been reported to show minimal or negligible effects of ISA on driving behaviour, as results are most time significantly below the speed limit and hence reducing the effect of ISA (Agerholm, 2011; Biding & Lind, 2002).

Although statistically significant, the reductions in mean speed revealed in this study are somewhat higher, but comparable, given the different circumstances (driving context and environment). One likely explanation is that, the mean speed of drivers' in the current study at baseline was relatively higher than the speed limit (50 and 60 km/h speed zones). Therefore, there may have been relatively higher opportunity for the ISA system to affect their speeds given that the drivers' were already travelling at higher speeds. However, in the 80 km/h road sections, the drivers' were quite conservative with their speed choice, their mean speeds before the ISA system was used were below the speed limit, yet still had large reductions. A possible reason could be that the legal speed limit might have been higher than drivers' choice of speed or the road condition. Finally, the results show that the use of ISA truncated mostly the higher ends of the speed distribution, with minimal changes to the lower speeds. As a result, the net mean speed reductions were higher.

For the SAC intervention, a significant mean speed reduction was observed at around 8, 10, and 11km/h respectively for 50, 60 and 80 km/h speed zones. While a number of previous studies have examined educational interventions on speeding behaviour, they have generally focused on the interventions changes influencing cognition or self-reported behaviour, rather than having examined changes in observed mean speed. In one of the few published studies to examine changes in mean speed using an educational campaign, Hou et al. (2012) found the mean speed reduced by around 2 km/h after the intervention. However, in a more recent study, Siregar (2018) investigated the effectiveness of training on the speed choice of Indonesian drivers. Compared with baseline levels, his training intervention produced slightly higher mean speeds, though there was no statistical significance. The current finding that drivers' mean speed reduced with the Speed awareness course is slightly higher to that of Hou et al. (2012). A plausible explanation for the higher reductions is likely the differences in methods, data collection, and sample population. The course in this study was hinged on a theory and could have been more effective in changing participant's behaviour. The findings fully support H5a and H5b which proposed that both interventions will significantly reduce drivers' mean speed.

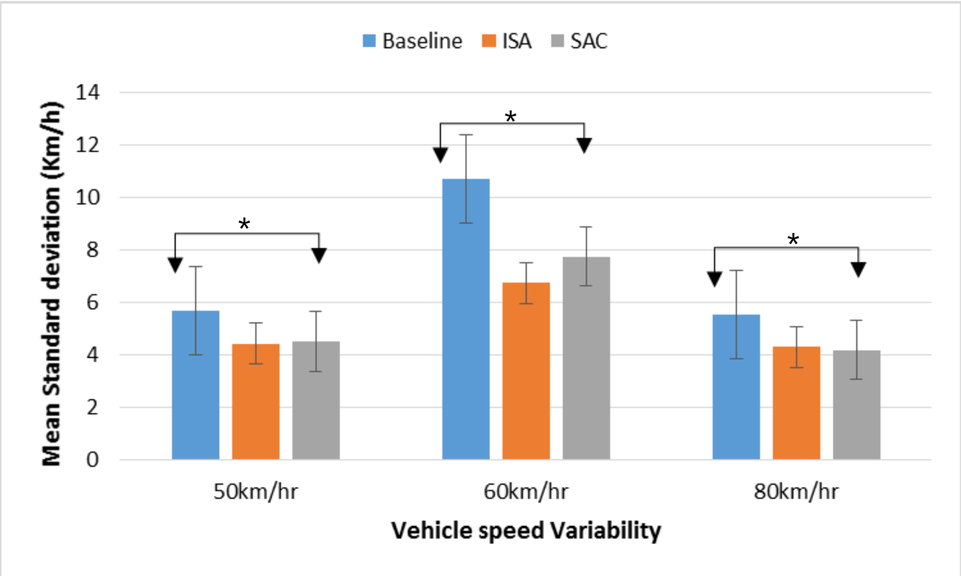
In conclusion, it is important to note that even minimal difference in mean speed could have a great effect on safety (Finch et al., 1994), thus, findings from this study could serve as a framework for a more general population study.

8.4.3 Standard deviation of speed (Speed Variability)

The standard deviation of speed shows the range of speed within a particular road segment, with small margins indicating that most of the traffic is driving at a similar speed (Agerholm et al., 2008b). Research has shown that the amount of speed variation influences crash rate, with higher variation of speed resulting in more crashes (Finch et al., 1994; Stuster & Coffman, 1998). Hence a decrease in standard deviation of speed by drivers' will greatly improve traffic safety (Kockelman & Jianming, 2007; Agerholm et al., 2008a).

Results from one-way repeated measures ANOVAs revealed that speed variability was significantly reduced by both ISA and SAC interventions at a p<.01 level, across all speed zones. **50km/h speed zone** [F (2, 38) = 6.7, p<.01], **60km/h speed zone** [F (2, 38) = 10.9, p<.01], and **80km/h speed zone** [F (2, 38) = 10.9, p<.01]. However, the Post hoc comparisons using the Bonferroni t-test indicated that there was no significant differences in speed variance between both ISA and SAC periods, across all speed zones, suggesting that both interventions were comparable in terms of speed variability.

Overall, the findings showed a clear decrease in speed variance (see Figure 31), and this effect is largely due to reduction in the high speed end of the distribution.



*** p <.01, ** p <.05, NS: Not significant**

Figure 31: Standard deviation of vehicle speed of participants across all speed zones and phases

As hypothesised, speed was less variable when the advisory ISA system was active, and this was across all speed zones examined. The system was significantly effective in reducing standard deviation by up to1.2km/h in both 50 and 80km/h speed zones and, 3.96km/h in the 60 km/h zone. It should be noted that the standard deviation of speed for the 60km/h roads was higher in the baseline period. These findings are very much consistent with past on road studies examining the effect of ISA warning systems on the variability of speed (Brookhuis & de Waard, 1999; Ghadiri et al., 2013; Regan et al., 2006a; Agerholm et al., 2008a) which found speed variability reductions of up to 3.8km/h. As revealed by the speed distribution, the decrease in variability is largely due to decrease in the highest speeds. However, although the lower speed distribution was minimally changed, drivers' still spent less time at speed well below the speed limit and this could also have contributed to the reduction in speed variation.

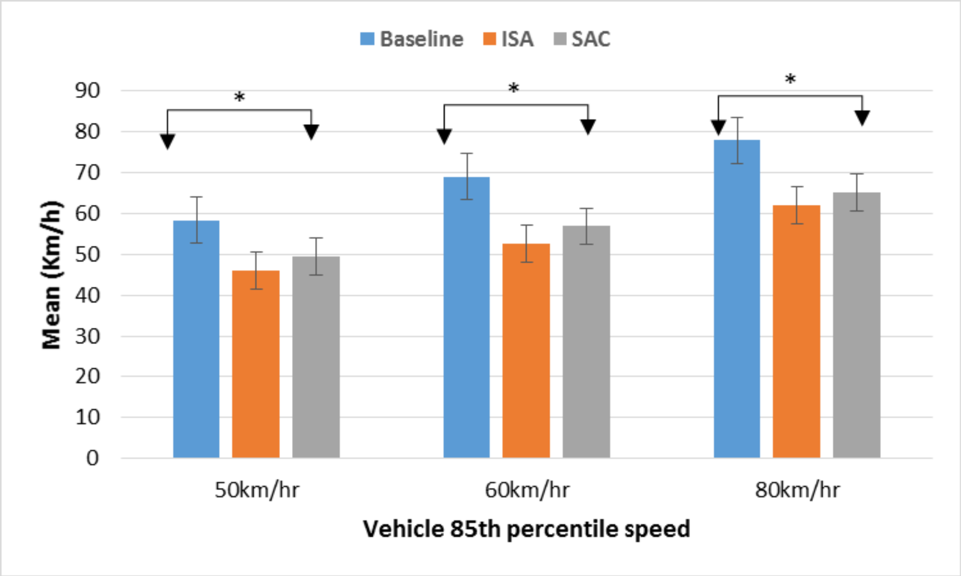
It was initially predicted that drivers' speed variability would decrease after the SAC. The results can confirm that after the course, the standard deviation reduced significantly by 1.2km/h, 3 km/h and 1.3km/h in 50, 60 and 80km/h speed zone respectively. Previous studies by Hou et al. (2012) and Siregar (2018) showed a non-significant increase in speed variability of 2.3km/h and 0.3km/h respectively.

Examining both countermeasures, even though there was slight increase in the lower speed during ISA usage compared with SAC levels, there was no significant differences in the speed variability between them. Overall, the findings support H6a and H6b which proposed that both intervention will significantly reduce drivers' speed variability across all speed zones.

8.4.4 85th percentile of speed

Several studies (Regan et al., 2006a; Várhelyi et al., 2004; Brookhuis & de Waard, 1999; Ghadiri et al., 2013) have measured the effect of speeding interventions by observing changes in the highest speed. The 85th percentile speed serves as a good indicator, of speed changes from interventions, by eliminating any bias from either idling, or driving in congestion. It has been reported to show noticeably more significant results than the mean speed (Ghadiri et al., 2103; Carsten et al., 2006; Regan et al., 2006a). The 85th percentile speed is a metric used for setting up speed limits of road sections, and is used in highway engineering, either for design, or safety purposes. According to UK Design manual for road and bridges (1981), the 85th percentile speed is the speed only exceeded by 15% of the cars under free flowing conditions.

Similar to the mean speeds, the speed at which 85% of the participants drove at, or below, at baseline period were higher than the speed limits in the 50 and 60km/h speed zones, and below the speed limit on the 80km/h zone. The 85th percentile speed at both intervention periods were below the speed limits across all speed zones.



* p <.01, ** p <.05, NS: Not significant

Figure 32: 85th percentile speed of vehicle speed of participants across all speed zones and phases

A one-way repeated measures ANOVA was conducted to compare the effects of the interventions on the 85th percentile speeds. Results showed significant reduction of mean speeds from baseline at p<.01 level for both ISA and SAC at all speed zones. **50km/h zone** [F (2, 38) = 96.1, p <.01], **60km/h zone** [F (2, 38) = 69.5, p<.01] and **80km/h zone** [F (2, 38) = 64.9, p<.01]. Post hoc comparisons using the Bonferroni t-test indicated that the 85th percentile speed reduction during the ISA intervention (M= 46.1 & 52.5 M=) was significantly different than the SAC (M= 49.6 & 56.9) intervention at the 50 and 60km/h zones respectively. However, the 85th percentile speeds during ISA intervention did not significantly differ from those during SAC intervention in the 60 and 80km/h speed zones. See Table 12 and Figure 32 for details.

The interventions saw a larger decrease in the 85th percentile speed when compared with mean speed. This is similar to studies by Lai et al. (2012b) and Regan et al. (2005) who both reported an advisory ISA reducing excessive, and high end of the speed distribution.

These observed reductions in the 85th percentile speed are consistent with the results of past studies, which have found the advisory ISA particularly effective in reducing the highest speeds (by up to 5.5km/h) depending on the speed zone (Regan et al., 2006a; Ghadiri et al., 2013). However the relative higher reductions in this study (up to 21%

reduction) can be attributed to the drivers' in the current study driving at relatively higher end of the speed distribution, at baseline, than those in previous studies. Also, some previous advisory ISA studies showed observable, but relatively small reductions (Lai et al., 2012b, Agerholm et al., 2008a), which attributed to the system curtailing speeding in a range that was relatively close to the speed limit.

As expected, drivers' 85th percentile speed was significantly reduced after the SAC. This reductions was up to 15% across the different speed zones. This result is a lot higher than those of Hou et al. (2012) who also examined the effect on an educational intervention on drivers' 85th percentile speed. In the Hou et al. study the educational campaign could not significantly reduce the 85th percentile speed.

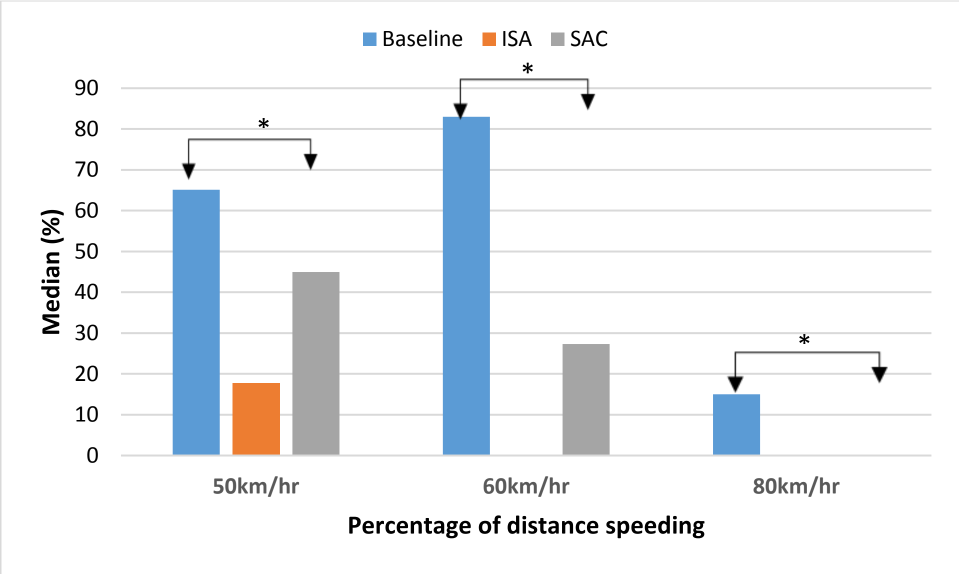
In summary, a major effect of the interventions were observed at the highest speed, and changes in the 85th percentile speed is a very good indicator of this. Also, the findings support H7a and H7b which proposed that both intervention will significantly reduce drivers' 85th percentile speed across all speed zones.

8.4.5 Percentage distance travelled above the speed limit (PDAS)

The variance in driver's speed limit violations and the interventions were accounted for by using the percentages of the total distance driven above the speed limits at the different speed zones. Studies by Lahrmann et al. (2012); Lai et al. (2012) and Vlassenroot et al. (2007) have all found this indicator as a better way of expressing the effectiveness of interventions rather than just overall speed reductions. The PDAS tends to remove biases in low speed (e.g. speed in congestion and intersections). It is important to note that, in this study, the threshold speed at which a driver is said to be speeding is 1km/h at or above the speed limit.

The PDAS in this study, was first examined for exceedance by 1km/h or more above the speed limit, as this is the threshold at which the ISA system commenced issuing speed warnings. Other thresholds of 1-5, 6-10 and +10km/h speed violation were examined, to determine the distance drivers' engaged in mild and moderate over-speeding (Regan et al., 2006a).

The data was examined for its distributional properties, with departures from normality occurring, and some heterogeneity of within-participants factors variance. Thus, the non-parametric Friedman test was used (an alternative to the one-way ANOVA). Table 12 shows the median percentage of distance travelled above 1km/h above the speed limit across the different speed zones. The percentage speeding of the different speed limit zones were weighted by distance, and averaged across road types. Results revealed a significantly difference from baseline level levels across all speed zones; 50km/h [$X^2(2)$ =33.6, p<.01], 60km/h [$X^2(2)$ =31.2, p<.01], and 80km/h [$X^2(2)$ =25.4, p<.01]. Post hoc t-tests showed both intervention comparatively reduced speed violation across all speed zones (p>.05). Evidently, speed limit violation was more prevalent in the baseline phase, with the highest amount of speeding per distance occurring in the 60 km/h zone (83.01%). Also, there appeared to be more percentage distance speeding on roads with lower speed limits, across all the phases, whilst the effect of both interventions were much more prominent on the higher speed zones (80km/h roads), showing a 100% reduction. See Table 12.



*** p <.01, ** p <.05, NS: Not significant**

Figure 33: Percentage of distance travelled at 1km/h or more above the speed limits

As predicted, the ISA system was effective in reducing the proportion of distance travelling at 1km/h or above, the speed limit across the different speed zones. When the ISA system was active, the median percentage reductions across speed zones in the percentage of distance spent travelling above the limit or 1km/h were 72.75% for the 50km/h roads and an identical 100% for the 60 and 80km/h roads. The results though higher, are in line with those of Lahrmann et al. (2012) and Lai et al. (2012) who in their studies found ISA to reduce speeding by up to 44 and 70.5% respectively.

As projected, after the SAC, the percentage of distance driven at or above the speed limit by 1km/h was significantly reduced by up to 31, 67 and 100% at 50, 60 and 80km/h speed zones respectively. As there are no previous studies that have collected objective behavioural data with respect to percentage of distance driven above the speed limit, it is not possible to directly compare the results of the effectiveness of SAC intervention in this study on driver speeding behaviour.

These results have revealed that the greatest effects on speed violation reduction was in the 80km/h speed zones, where speeding is almost eliminated. According to Agerholm et al. (2008a) drivers' tend to show higher acceptance of urban speed limits than rural, which explains this finding.

The results also revealed that there was no statistically significant difference between the effects of ISA and SAC in speed reduction, and that both interventions were effective in reducing speeding across all speed zones which is in support of Hypotheses 5a and 5b.

8.4.5.1 PDAS examined using three thresholds

When the PDAS was examined using the thresholds of 1-5km/h, 6-10km/h, and +10km/h, the results in summary show that while there is evidence of reduction of speeding across the different thresholds, compared with baseline levels. However there is no particular trend or relationship between the different speeding thresholds and the various interventions across the different speed zones. (See Table 12). This thresholds were examined, to determine the distance drivers' engaged in mild and moderate over-speeding.

8.4.6 Driver-specific analysis of percentage distance speeding

The effect of the interventions on total speeding is already mentioned above. The effects of the intervention on speed limit violation, per distance travelled were largest during ISA usage, compared with the SAC drives, and largest in the 80km/h speed zones. To study the effects of the interventions in more detail, results are given per driver in Figure 34 below.

Differences between the drivers' were large, especially at the baseline and SAC (50 and 60 km/h zones) phases. Distance speeding during baseline varied between 50%-80%, 50%-90%, and 0% -78% in the 50, 60 and 80km/h speed zones respectively. With ISA this varied between 1%-30%, 0%-40% in the 50 and 60 km/h zone respectively. The variability in distance speeding during SAC was between 10% - 60%, 0% - 90% and 0% to 40 at the 50, 60 and 80 km/h speed zones respectively.

For most drivers, speeding reduced with the interventions. There are, however, 2 out of the 20 drivers for whom speeding increased during the SAC phase in the 60km/h speed zone (drivers 7 and 10). This increase could either be attributed to the traffic condition during their drives or other uncontrolled variables.

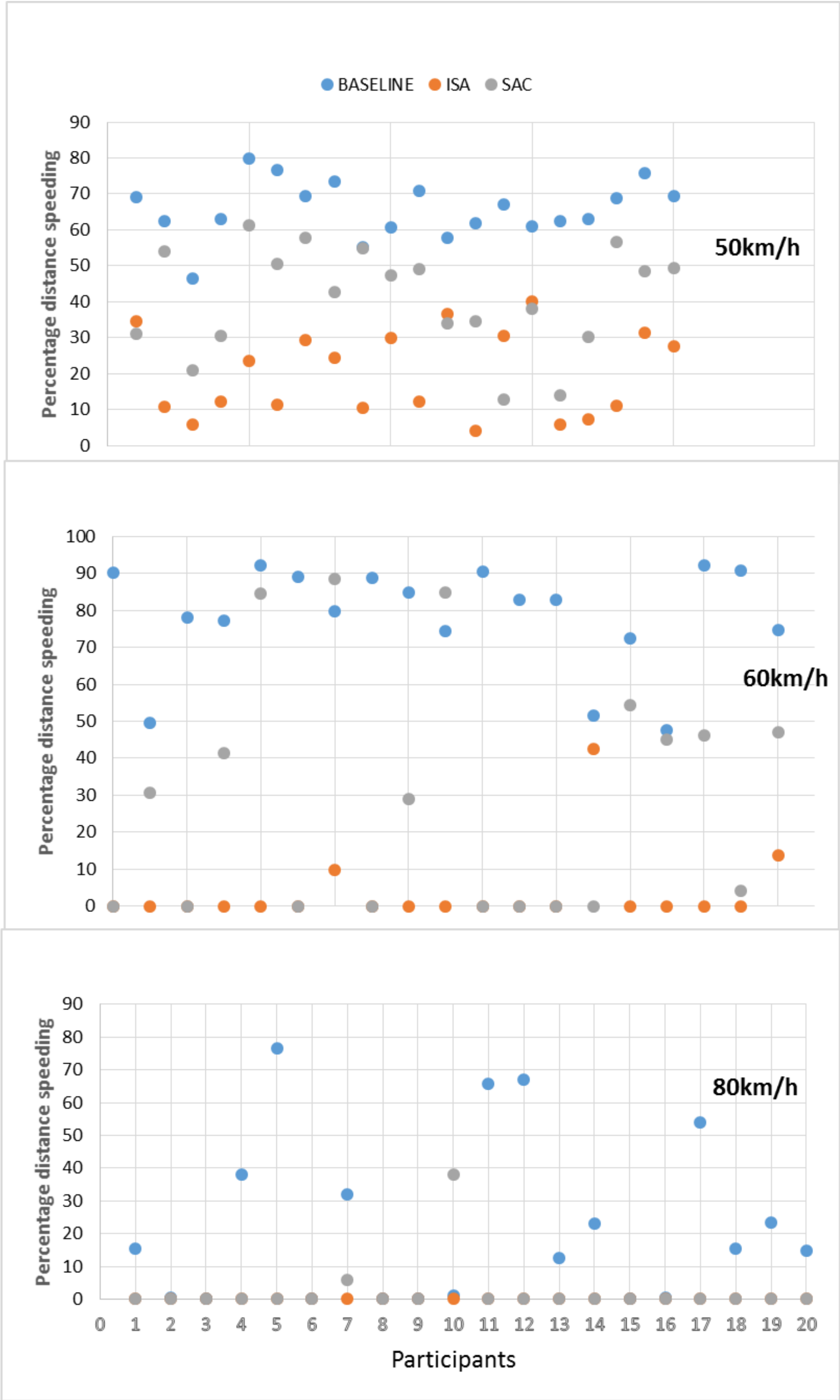


Figure 34: Percentage of total distance driven above the speed limit per driver

Table 12: Summary of all speed indicators across the different speed zones and phases

Indicator	Speed Zone (Km/h)	Mean			Repeated Measures ANOVA	Effect sizes $\dot{\eta}^2$ (ω^2)	Post hoc t-tests		
		Baseline	ISA	SAC					
Mean Speed	50	53.2	42.7	45.6	F (2, 38)= 75.1,p<.01	.79 (.71)		**ISA**	**SAC**
							Baseline	*	*
							ISA		**
	60	62	48.6	52.2	F (2, 38)= 41.9,p<.01	.87 (.58)		**ISA**	**SAC**
							Baseline	*	*
							ISA		NS
	80	73.6	58.6	61.7	F (2, 38)= 69.8,p<.01	.79 (.69)		**ISA**	**SAC**
							Baseline	*	*
							ISA		NS
Standard Deviation	50	5.7	4.4	4.5	F (2, 38)= 6.7 ,p<.01	.26 (.16)		**ISA**	**SAC**
							Baseline	*	**
							ISA		NS
	60	10.7	6.8	7.8	F (2, 38)= 10.9,,p<.01	.37 (.25)		**ISA**	**SAC**
							Baseline	*	*
							ISA		NS
	80	5.6	4.3	4.2	F (2, 38)= 10.9, p<.01	.36 (.25)		**ISA**	**SAC**
							Baseline	*	*
							ISA		NS
85^{th} Percentile Speed	50	58.3	46.1	49.6	F (2, 38)= 96.1,p<.01	.84 (.76)		**ISA**	**SAC**
							Baseline	*	*
							ISA		*
	60	68.9	52.5	56.9	F (2, 38)= 69.5,,p<.01	.79 (.69)		**ISA**	**SAC**
							Baseline	*	*
							ISA		**
	80	77.8	61.9	65.1	F (2, 38)= 64.9, p<.01	.77 (.68)		**ISA**	**SAC**
							Baseline	*	*
							ISA		NS

<table>
<tr><th colspan="10">Percentage of distance travelled above the speed limit</th></tr>
<tr><th rowspan="2">Speed Bin</th><th rowspan="2">Speed Zone (Km/h))</th><th rowspan="2">Total Distance of Speed zone (Km)</th><th colspan="3">Median Percentage distance Speeding above the limit (%)</th><th rowspan="2">Friedman ANOVA</th><th colspan="3" rowspan="2">Post hoc t-tests</th></tr>
<tr><th>ISA</th><th>SAC</th><th>Baseline</th></tr>
<tr><td rowspan="9">1Km/h</td><td rowspan="3">50</td><td rowspan="3">16.8</td><td rowspan="3">17.7</td><td rowspan="3">44.9</td><td rowspan="3">65.1</td><td rowspan="3">$X^2(2)=33.6$, $p<.01$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>.89*</td><td>.60*</td></tr>
<tr><td>ISA</td><td></td><td>-.29^{NS}</td></tr>
<tr><td rowspan="3">60</td><td rowspan="3">15.3</td><td rowspan="3">0</td><td rowspan="3">27.3</td><td rowspan="3">83</td><td rowspan="3">$X^2(2)=31.3$, $p<.01$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>.84*</td><td>.51*</td></tr>
<tr><td>ISA</td><td></td><td>-.32^{NS}</td></tr>
<tr><td rowspan="3">80</td><td rowspan="3">14.0</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">14.9</td><td rowspan="3">$X^2(2)=25.4$, $p<.01$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>.56*</td><td>.48*</td></tr>
<tr><td>ISA</td><td></td><td>-.074^{NS}</td></tr>
<tr><td rowspan="9">1-5 Km/h</td><td rowspan="3">50</td><td rowspan="3">16.8</td><td rowspan="3">6.7</td><td rowspan="3">13.4</td><td rowspan="3">14.9</td><td rowspan="3">$X^2(2)=5.2$, $p=.074$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>^{NS}</td><td>^{NS}</td></tr>
<tr><td>ISA</td><td></td><td>^{NS}</td></tr>
<tr><td rowspan="3">60</td><td rowspan="3">15.3</td><td rowspan="3">0</td><td rowspan="3">9.4</td><td rowspan="3">22.8</td><td rowspan="3">$X^2(2)=18$, $p<.01$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>*</td><td>^{NS}</td></tr>
<tr><td>ISA</td><td></td><td>^{NS}</td></tr>
<tr><td rowspan="3">80</td><td rowspan="3">14.0</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">14.9</td><td rowspan="3">$X^2(2)=20.3$, $p<.01$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>*</td><td>*</td></tr>
<tr><td>ISA</td><td></td><td>^{NS}</td></tr>
<tr><td rowspan="8">6-10Km/h</td><td rowspan="3">50</td><td rowspan="3">16.8</td><td rowspan="3">2.8</td><td rowspan="3">12.0</td><td rowspan="3">10.6</td><td rowspan="3">$X^2(2)=21.9$, $p<.01$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>*</td><td>^{NS}</td></tr>
<tr><td>ISA</td><td></td><td>*</td></tr>
<tr><td rowspan="3">60</td><td rowspan="3">15.3</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">22.8</td><td rowspan="3">$X^2(2)=34.3$, $p<.01$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>*</td><td>*</td></tr>
<tr><td>ISA</td><td></td><td>^{NS}</td></tr>
<tr><td rowspan="2">80</td><td rowspan="2">14.0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">$X^2(2)=8.9$, $p<.05$</td><td></td><td>ISA</td><td>SAC</td></tr>
<tr><td>Baseline</td><td>^{NS}</td><td>^{NS}</td></tr>
</table>

							ISA		NS
+10Km/h	50	16.8	3.1	6.8	32.3	$X^2(2)=23.7$, p<.01		**ISA**	**SAC**
							Baseline	*	*
							ISA		NS
	60	15.3	0	0	26.6	$X^2(2)=23$, p<.01		**ISA**	**SAC**
							Baseline	*	*
							ISA		NS
	80	14.0	0	0	0	$X^2(2)=4$, p=.135		**ISA**	**SAC**
							Baseline	NS	NS
							ISA		NS

*: p<.01 **: p<.05; NS: Not significant;
$\dot{\eta}^2$ = Partial eta squared (Sample effect size); ω^2 = Partial omega square (Population effect size).

8.5 Road safety estimation

According to Agerholm (2008), the low number of vehicles used in ISA trials makes it hard to measure the real road safety effects. To arrive at any conclusion about the effectiveness of ISA on safety, it is important to apply models relating to crash risk (Lai et al., 2012a).

For this study, the effect of the interventions on the prediction of how crashes would split between serious-injury and fatalities was estimated using coefficients from the Power model by Elvik (2009). The effect of ISA on serious-injury crashes, based on reductions in the mean speed, was estimated to be 44-47% and a 59- 63% reduction in fatal crashes. On the other hand, the effect of SAC was in the order of 33-39%, and 47-52% for serious-injury crashes and fatal injury crashes, respectively (See Table 13). In the report outlining the results of the external vehicle speed control in the UK, Carsten & Fowkes (2000), estimated a reduction of up to 10-18% in serious-injury and fatal crashes from an Advisory ISA. Regan et al. (2006) and Ghadiri et al. (2013), estimated between 5.8 – 23% reductions of fatal crashes. The results from the current study appear to be higher than past studies, and the possible reason could be that, the Power Model by Nilsson (19982) was calibrated for high income countries, which have higher quality of roads and infrastructure, and better traffic laws. Hence, its application in lower and middle income countries noted for higher burdens of road traffic crashes and fatalities, lower seat belt wearing, and less protective vehicles might differ. There is likelihood that the exponents might be higher, therefore the Power Model will predict that a crash at a given speed is more likely to result in severe outcomes in developing nations (bringing higher estimates), as opposed to developed nations.

The results from this study should be treated with caution due to the small sample size used, and the specific nature of the sample drivers. Estimates from the study have not been observed in real-world implementations of these interventions and thus cannot provide an accurate estimation of crashes and injuries outcome for the general population.

However, to the best of the researcher's knowledge, this study is the first to estimate accident-saving benefits from an educational intervention, with findings showing some level of potentials for such interventions.

Table 13: Estimates of crash savings by ISA and SAC and by severity

Speed Zone (km/h)	Mean Speed (km/h)			Expected decrease in the number of serious injury crashes		Expected decrease in the number of fatal crashes	
	V_1	V_2		$(1-(V_2/V_1)^{2.6})*100$		$(1-(V_2/V_1)^{4.1})*100$	
	Baseline	ISA	SAC	ISA	SAC	ISA	SAC
50	53.2	42.7	45.6	44%	33%	59%	47%
60	62	48.6	52.2	47%	36%	63%	50.6%
80	73.6	58.6	61.7	45%	39%	61%	52%

Where V_1 = before intervention; V_2= after intervention

8.6 Conclusion

This study showed no particular trend of whether if speed limit violations/proportion of distance driven above the speed limit, were dependent on posted speed limit, neither was there any trend showing that reduction in mean speed or 85th percentile speed was reliant on the speed limit. However, the study showed that the reduction in the proportion of distance driven above the speed limit increased with higher speed limits. Comparing the reductions in terms of intervention, it can be clearly seen that the ISA systems caused higher reductions compared with the SAC intervention, with regards to mean speed, 85th percentile speed, and speed variability. However, there was no significant differences between the interventions, when considering the percentage of distance travelled above the speed limit.

The present study has shown that, overall, results from the advisory ISA system and SAC are very promising. Consistent with the fourth hypothesis, the results show that both ISA and SAC were able to reshape the speed distribution and move it to the left. In line with the second, third and fourth hypotheses, the results also show that both countermeasures were effective in reducing mean speed, reducing speed variability and curtailing speeds at the high end of the speed distribution, across all speed zones. As predicted in the fourth hypothesis, the interventions significantly reduced the percentage distance of speeding above the speed limit. Besides this, driving above the speed limit was almost eliminated in the 80 km/h speed zone.

Although both intervention were effective across all speed zones, there was some level of differential effects across the different speed zones. Whilst this is not limited to this study, it is likely this differences would have been from factors such as; different traffic conditions, and the different infrastructure present in each speed zone. For instance the 80 km/h roads had more road signs and furniture than other roads.

It has also been shown that education can be an effective countermeasure in modifying drivers' speeding behaviour. The present study is a first in Nigeria (and probably all of West Africa), and overall the results and findings have shown a significant potential of an advisory ISA and SAC to alter drivers' speeding behaviour. Also, to the best of the candidate's knowledge, this is the first study to have tested the efficacy of both interventions on the private setting of drivers' who work in a company with strong safety culture.

Table 14: Summary of reduction in speeds by the interventions

Reduction in speed and speed limit violation in the ISA condition			
	50	**60**	**80**
Mean Speed	-19.7%*	-21.6%*	-20.4%*
85^{th} Percentile	-20.9%*	-23.8%*	-20.5%*
Speeding	-72.75%	-100%	-100%
Reduction in speed and speed limit violation in the SAC condition			
	50	**60**	**80**
Mean Speed	-14.7%*	-15.9%*	-16.2%*
85^{th} Percentile	-15.2%*	-17.5% *	-16.3%*
Speeding	-30.93%	-67.08%	-100%

8.7 Limitation of study

There are a number of limitations in the study that could be addressed in future trials. These limitations have been categorised into: methodological and technical issues.

8.7.1 Methodological issues

The use of volunteer drivers in the study is an inherent challenge, and apparently an inevitable condition in most studies. It is possible that participants who volunteered in the study were more safety conscious than those who did not participate. According to Elvis (2002), even volunteers with a negative attitude towards an intervention, are likely to be more compliant than the majority of the drivers' if coerced in to driving with a speed-reduction technology.

Since the study involved drivers' who worked in a company with a strong safety culture, it is also possible that the drivers' may have been more safety conscious, than the general driving population, due to either anticipated regret of losing their jobs or bias in their behaviour. To mitigate this, participants were told the study was strictly for academic purposes and all data would be strictly and completely anonymized.

However, since the study was focused on using fleet drivers who work under strong safety culture and owned and drove their own private vehicles, the use of volunteers was unavoidable. Moreover, use of such drivers' served as a control in the study, as drivers' were easy to manage and readily available.

The study utilised a small sample of drivers', with only 20 drivers participating in the study. This was smaller than originally planned (N=30); due to financial constraints for the research (as there was no external funding, with funding only from the lead researchers personal savings, and part of the researcher training support grant), and difficulties in recruiting eligible participants. A power analysis was conducted to determine if the sample size would compromise the statistical strength of the finding. Using G*Power 3.0 application a priori power analysis was run with a probability level (α) of 0.05, an anticipated effect size of 0.30, and the desired statistical power level of 0.85. Results revealed there is an 82% chance of correctly rejecting the null hypothesis of the significant effect of the interventions with a total of 22 participants. This finding suggests the integrity of the findings from the study would not be seriously compromised using a sample size of 20.

Another limitation of the study was the participation of only male drivers... This was due to the fact that fleet and commercial driving in general is dominated by men in Nigeria. According to Regan et al. (2006a), using male only, middle-age and experienced participants, with a large mileage per year, is likely to have minimal gender differences.

There was also the issue of driver attrition. During the baseline phase 30 drivers indicated interest in taking part in the study, but over the course of the study, 5 did not show up for the drives, and the other 5 terminated their participation in the study after the baseline drives. The terminations were mostly unrelated to the study circumstances, but were rather personal problems, busy work schedule, and health challenges, hence their premature departure from the study was beyond the control of the researcher.

The current study did not test participants knowledge of the facts about speeding and its consequences before or after the speed awareness course. Whilst the aim of the course was to modify participants' TPB constructs and observed behaviour, it would have been beneficial to assess drivers understanding and awareness of speeding. A test of knowledge would have provided a balanced and fair evaluation of each participant, by giving them the opportunity to demonstrate what they have learned in the course, and how they could use it in real life driving. It would also have tested if the course was appropriate or fit for purpose to its specific goals and objectives.

The current study also did not use a control group in the experimental design. A control group would have served as a benchmark, and allowed for the comparison with the experimental group, and also would have tested for impact changes to the independent variable. However, due to small sample size (from budgetary constraints), a repeated within-subject design was used with every participant subjected to every single intervention, including participant's acting as their own control (baseline).

The final methodological issue relates to the length of the study. Due to time and financial constraints, the evaluation of long term or carry-over effects of the interventions was not possible. It is likely that a further adaptation effect (e.g., reverting back to their old behaviour) would have been found, had the exposure periods been longer.

8.7.2 Technical issues

It was discovered during the baseline drives that the GPS devices were unable to save a large amount of data. This was remedied by transferring each participant's data into a computer after each drive.

During the pilot study, there was the issue of incorrect speed limits being displayed by the speed warning application, in some segments of the route. This inconsistency was either due to the limitations of the smart phone GPS receiver, or wrong digital map from the producers of the application. During analysis, data from those points and locations were excluded as coordinates of those locations where taken.

8.8 Future studies

Though the overall findings show significant potential of both the ISA system and SAC in influencing drivers' speeding behaviour, there is need for more research in this context, For example further studies will be needed to test the long term effect of the interventions on drivers' behaviour, to establish if effects observed in the current study were not sample due to novelty effect.

Secondly, studies involving a larger number of drivers' would be needed to examine how both countermeasures can be best implemented in Nigeria.

Future studies should involve testing participant's knowledge component before and after the speed awareness course.

Finally, future work could evaluate the combine effect of both intervention on drivers' choice of speed.

Chapter 9: Acceptance of ISA (Study 4)

9.1 Overview

This Chapter presents the findings from a quantitative study on the acceptance of the ISA system used in Study 3. It focuses on the predictive utility of the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003). The model postulates that Usage Behaviour is directly determined by 'Behavioural Intention. Behavioural Intention is in turn influenced by Performance Expectancy (PE), Effort Expectancy (EE) and Social Influence (SI) (Venkatesh et al., 2003).

This study examines how Performance Expectancy, Effort Expectancy and Social Influence affected drivers' Intention to use the ISA system. It was envisaged that, if drivers' speeding behaviour is to be modified using ISA systems, it is important that prospective users accept the systems.

The UTAUT model has mostly been used in the context of information/communication systems, with only a few past studies in the domain of driver support systems (Adell, 2009; Lai et al., 2012b; Madigan et al., 2016). While these studies have all found relative utility of the model, they have been mostly used on general population drivers and in the western cultural context.

The specific objective of the Study reported here was to use an adapted version of the UTAUT model to understand acceptance of an Advisory ISA system, among Nigerian drivers' who worked in a company with a strong safety culture.

The current Study attempts to answer particular questions pertaining to the relationships among the UTAUT constructs: Performance Expectancy (PE; which is the degree to which an individual believes that using the system will help him or her to attain gains in job performance), Effort Expectancy (EE; the degree of ease associated with the use of the system), Social Influence (SI; the degree to which an individual perceives that important others believe he or she should use the new system) and Intention (motivation) to use an ISA system. The study also seeks to examine the changes in acceptability levels over time. Thus, the following research questions were outlined:

RQ6. What are the determinants of intention to use an ISA system? In other words how much impacts do PE, EE and SI have on Behavioural Intention?

RQ7. Is there differences in driver's acceptability of the ISA system after usage?

9.2 Methods

9.2.1 Procedure

Participation in this study was part of the main study (Study 3). The questionnaire for this study was adapted from the one used by Lai et al. (2012b) to investigate the acceptability of an advisory ISA. The driver ISA acceptance survey consisted of 11 items measuring the constructs of the UTAUT model (see section 4.6 for literature).

The survey was self-administered in paper form and completed prospectively at two time intervals (between November 2016 and February 2017), with participants completing the survey before, and after the use of the ISA application. All items were measured using a 5-point Likert scale (scored 1-5 for low to high acceptability). Each construct of the model was measured with respect to the speed warning application and speeding. The questionnaires were completed anonymously before and after the ISA drive, and took between 5 and 7 minutes to complete. See appendix A.3 for a copy of the questionnaire.

9.2.2 Questionnaire measure

Performance Expectancy, Effort Expectancy, Social Influence, served as the independent variables, while Behavioural Intention was the dependent variable. The internal consistencies of the scale were measured using the Cronbach Alpha coefficient (α), which according to Nunally & Bernstein (1994) should be above 0.70 to reliably measure a construct.

Performance Expectancy (PE): Five items were used to measure PE towards the use of the Advisory ISA (e.g. "The speed warning application system will be effective in reducing my speed". Cronbach alpha was reasonable at both Time 1 α =.73 and Time 2, α =.79.

Effort Expectancy (EE): Two items measured the degree of ease associated with the use of the system (e.g. "Learning to operate the speed warning application system will be easy for me"). Internal consistency was low at Time 1 α = .42 and very high at time 2, α =.91

Social Influence (SI): The degree to which an individual perceives that important others approve their use of the system was measured with two items. (e.g. "My employer will support my use of the speed warning application system"). Cronbach's alpha was .78 and .58 at Time 1 and 2, respectively.

Behavioural Intention (BI): Intention to use the system was measured with two items. (e.g. "I plan to use the speed warning application system"). It had a very high internal consistency of α = .72 and 1, at the two time intervals, respectively.

9.3 Data analysis

For this study, all data were analysed using the Statistical Package for the Social Science (SPSS Version 22) and Microsoft Excel (Version 2013). Before analyses, data were screened for accuracy of entry. There were no missing data from the received questionnaires.

9.3.1 Measures of validity

A factor analysis was conducted, using Principal Components Analysis (PCA), with Varimax rotation to investigate if the UTAUT constructs were distinct. Individual Kaiser-Meyer-Olkin (KMO) measures for all constructs were above 0.5 which according to Field (2013) is an acceptable limit for sampling adequacy. Barlett's test of sphericity was statistically significant ($p<0.05$), indicating that the data is likely factorable. An examination of the Scree plot and Kaiser (1974) criterion of eigenvalues greater than 1 showed 3 clear factors emerging, explaining 67.6% of the total variance (i.e. 38.8%, 17.2%, and 11.6%). Question 5 of PE showed a low influence, hence was removed from the PCA. As can been seen in Table 15, only items under Performance Expectancy, Effort Expectancy and Behavioural Intention had good discriminant validity, as they had obvious large loading in their corresponding components. The Social Influence factors were not consistent in their loading, which could have been as a result of the short scales (only 2 items), which according to Madigan et al. (2016) is common in the UTAUT literature. However, the contents of the items were considered valuable hence were maintained in the analyses.

Table 15: Component loadings for UTAUT items measured

Items	**Component**		
	1	**2**	**3**
Performance Expectancy			
1. The speed warning application system will be effective in reducing my speed.	**.66**	.21	-.08
2. Will drive more safely with the speed warning application system.	**.70**	.15	-.001
3. Using the speed warning application system will improve my driving performance.	**.75**	.27	-.001

4. I will find the speed warning application system useful when I drive.	**.80**	.30	-.04
Effort Expectancy 1. Learning to operate the speed warning application system will be easy for me. 2. I will find the speed warning application system easy to use.	-.24 .14	-.03 .10	**.78** **.88**
Social Influence 1. My employer will support my use of the speed warning application system. 2. People who are important to me will support that I should use speed warning application system.	.48 **.75**	-.01 .020	**.52** .31
Behavioural Intention 1. I intend to use the speed warning application system. 2. I plan to use the speed warning application system.	.24 .25	**.91** **.90**	.03 .04

Note: Major loadings for each item are in bold.

9.3.2 Correlation of the UTAUT constructs

The mean scores for each two time points are shown in Table 16 with, 1 = low acceptability of ISA system, and 5 = high acceptability.

Spearman correlation analysis was used to test the relationships among the UTAUT constructs, at both Time 1 and 2, as can be seen in Table 16. They appear to be significant correlations between the constructs, indicating they may be measuring the same underlying acceptability (Lai et al., 2012b). The highest correlation was 0.6, which is moderately low to rule out multicollinearity.

Table 16: Descriptive statistics and correlations between UTAUT constructs

Variable	Time 1					Time 2				
	Mean (SD)	**PE**	**EE**	**SI**	**BI**	**Mean (SD)**	**PE**	**EE**	**SI**	**BI**
Performance Expectancy (PE)	4.24 (0.51)	-	0.43	**0.53[a]**	**0.55[a]**	3.79 (0.76)	-	-0.11	0.38	**0.64[b]**
Effort Expectancy (EE)	3.97 (0.71)	0.43	-	0.23	0.24	3.95 (0.75)	-0.11	-	0.33	-0.05
Social Influence (SI)	4.35 (0.48)	**0.53[a]**	0.23	-	0.32	3.90 (0.62)	0.38	0.33	-	0.23
Behavioural Intention (BI)	4.00 (0.87)	**0.55[a]**	0.24	0.32	-	4.05 (1.05)	**0.64[b]**	-0.05	0.23	-

Note: A high mean value indicates PE, EE, SI and intention in favour of acceptability of ISA.

a= Correlation is significant at the 0.01 level (2-tailed) ($P <.01$)
b= Correlation is significant at the 0.05 level (2-tailed) ($P <.05$)

9.4 Results and discussion

9.4.1 Predicting behavioural Intention

In accordance with the UTAUT model, that the three direct determinants of Intention to Use are Performance Expectancy, Effort Expectancy, and Social Influence (See section 4.6), a multiple regression analysis was carried out for both Time 1 and 2 data, to examine the relationship between the independent constructs.

There were constraints in item development arising from the fact that the Advisory ISA was temporarily used in the study, and only in their private vehicles. The UTAUT constructs of Usage and Facilitating Conditions could not be varied and therefore are not investigated. However, past studies show that FC does not explain any variance in the Intention to use. (Venkatesh et al., 2013). Also, the UTAUT model has four moderators: gender, age, experience, and voluntariness. For this study, these were all excluded, due to experimental constraints (participants were all males, there was little spread of participants age, participants had little or no prior experience with the system and the behaviour under consideration is discretionary and totally voluntary).

Before the analyses, the data were checked to meet the assumptions required for the test. A-Durblin-Watson statistics of 2.3-2.2 assessed the independence of the observations. There was moderate linearity and homoscedasticity, as assessed by a visual inspection plot of the studentised residuals, versus unstandardized predicted values. There was no multicollinearity between variables, as there were no correlations larger than 0.7 in the data. Residuals were approximately normally distributed.

The predictive power of the UTAUT model was only significant at Time 2, explaining 36% of the variance in Intention to Use [$F(3, 16) = 4.48$, $p<0.05$].This finding partially supports Hypothesis 5, which proposed a significant prediction of acceptance at both time intervals.

A possible explanation for the inability of the model to significantly predict Intention at Time 1, could have been as a result of some preconceptions held by participants (Lai et al., 2012b) at this phase, as data in Time 1 was collected prior to the participants having experience with the ISA system. Expectations regarding system acceptability by drivers' is limited when made in advance as in this study (Langer et al., 2017), as there is no prior experience to compare with.

The standardised beta coefficient revealed that the impact of Performance Expectancy appeared to be the only significant predictor of Intention [$\beta = .57$, $p<0.05$]. The results of the tested model are summarised in Figure 35 while the regression coefficient and standard errors can be found in appendix A. 9.

Data suggest that, the more a participant believes that using the system will help him to attain gains in job performance, the more likely their Intention to Use the system. This result is consistent with Venkatesh et al. (2003); Adell (2009) and Madigan et al. (2016), in their proposition that Performance Expectancy is the strongest predictor of Intention to Use. This finding suggests that the gains in terms of performance of the technology is the main component in the choice of accepting it or intending to use it.

This study did not find either Effort Expectancy (similar to Adell, 2009) or Social Influence to be significant predictors of Behavioural Intention at either time periods. Unlike Information technology (example, computer program) for which the UTAUT model was developed for, and which requires action by the user, the ISA system in this study required less inputs/effort by the driver. Further the strong social dimension of driving compared with information technology was expected to have significantly influence Intention to Use. But this was not the case with a possible reason being the short time drivers had to use the system.

Overall, the findings show that the basic UTAUT model was able to partially predict Behavioural Intention, with results relatively similar to past studies that found PE to be the strongest determinant of Intention (Madigan et al., 2016; Adell, 2009).

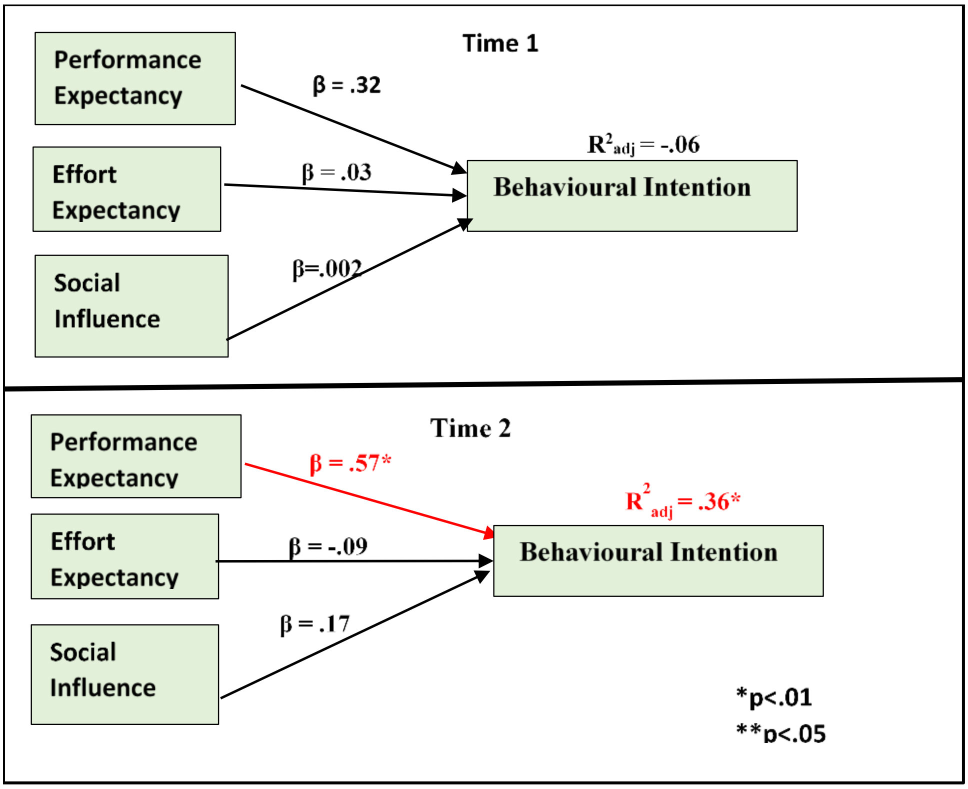


Figure 35: Standard regression weights for PE, EE and SI explaining variance by the UTAUT model for Intention at Time 1 and Time 2

9.4.2 Comparing UTAUT constructed over time

To establish if participant's acceptance levels changed over time, a Wilcoxon signed-rank test was carried out on the data. Relative changes in scores at Time 1 and 2 suggest that, to a certain level exposure to the ISA influenced acceptance.

Table 17: Results of statistical analysis of the UTAUT constructs, over time

Variables	Median		Paired Differences
	Time 1	Time 2	
Performance Expectancy	4.3	3.9	Z (19) = -2.243; p= 0.025, p<0.05
Effort Expectancy	4.00	4.0	Z (19) = 0.027; NS
Social Influence	4.00	3.75	Z (19) = -2.553; p= 0.011, p<0.05
Behavioural Intention	4.00	4.00	Z (19) = -.058; NS

Results, as seen in Table 17, show that Performance Expectancy significantly decreased over time (meaning the degree to which they thought using the ISA system will improve their driving was reduced). This implies that after driving with the system, participants were not as impressed with the overall influence of the ISA on their speed choice, as they had initially thought, indicating less acceptability.

Acceptability scores relating to Social Influence also significantly decreased after experience with the ISA system. After using the ISA system, participants felt their employers/family/friends would still recommend usage, but with probably less enthusiasm. This finding is similar to Lai et al. (2012b) which to the best of the candidate's knowledge is the only other study to have prospectively measured User Acceptance of ISA. This finding partially supports Hypothesis 6, which predicted significant difference of the UTAUT, variables over time.

Finally results showed that Effort Expectancy and Behavioural Intention remained at same level over time.

One possible explanation for this reduction in acceptability levels could be drawn from the fact that, prior to the participants having any experience with the ISA system (i.e. Time 1), they only had preconceptions (likely high expectations) about the ISA system, and after usage, this initial preconception would have been replaced by evidence-based views (Lai et al., 2012b). According to Oei & Polak (2002) the acceptance of ISA is remarkably higher before the test than during and after the test. Therefore, it makes sense to build the relationship between the acceptability construct of the model on Time 2 data only. At Time 2, participants had driven with the ISA system, had evaluated their performance with the system, thus, and was the best time to make any evidence-based decision to use or not use the system.

9.5 Conclusion and research implications

This study adopted the UTAUT model to explain acceptability of an advisory ISA system, and, to the best of the researcher's knowledge, this is the first study which had tried to gain an understanding of drivers' acceptance of ISA systems as a driver support system in a Low income country, among fleet drivers' who work in a strong driving safety culture in their own private vehicles.

The findings from this study provide some support for the use of the UTAUT model as a framework for assessing acceptability of the advisory ISA system, although not that all cases of the original hypotheses were sustained. The UTAUT model suggest three influencing factors to explain Behavioural Intention. At Time 1, none of them were able to predict behavioural intention, this is not surprising, as only very few expectations regarding system acceptability can be made in advance when there is no prior experience to compare with (at baseline, drivers' were yet to use the ISA system).

Though slightly higher than those of Adell (2009) and Madigan et al. (2016) studies (20 and 22% respectively), the predictive power of 35% of the model at Time 2 in this study is slightly consistent with past studies in the driver assistance context by Langer et al. (2017) (46%). Also consistent with past studies, participants are driven to intend to use the ISA system mainly based on their Performance expectancy from using the system.

The findings suggest high acceptance levels from the drivers'. Drivers' demonstrated strong beliefs and positive Intention to Use the system. However, significant differences in PE and SI over time might imply that after using the ISA system (after Time 1), drivers' though impressed with the system, had to replace their initial acceptance with real-life experience. The high acceptability of ISA is similar to Biding & Lind (2002), who found that 50% of the drivers' who used a warning ISA are willing to pay to keep it.

The partial performance of the model in this study could be as result of the shortfall of the UTAUT model in taking into consideration all components which influences driver Intention to Use the ISA system, (Madigan et al., 2016). The UTAUT model was originally developed for use in information and communication technology, and differs from the driving context in which it was used in this study. According to Adell (2009), driving requires more social interaction than using a computer, it also requires less input/effort into the system compared with using a computer, and might have resulted in the poor performance of the model by the EE and SI constructs of the model. Therefore, as suggested by Lai et al. (2012b); Adell (2009) and Madigan et al. (2016), drivers' intention to use the ISA system, was hinged on emotive factors such as safety, enjoyment/comfort during use rather than its ease of use or what important others approved. Including these components in future is likely to increase the predictive power of the UTAUT model.

9.6 Limitations and future studies

The results from this study should be treated with caution due to small sample size and lack of long-term interaction, and experience with the system. This may limit the generalisability of the results. Future studies may produce findings based on a larger sample size, better spread of age and gender and over a longer time period.

This study was conducted in Nigeria, which is a country with a fast growing information and communication market. Usage of smartphones and availability of mobile internet is still very much limited and still in its infancy; therefore the results from this study cannot be generalised to other countries with relatively mature information and communication systems. A future study could examine how the results from this study could be compared with developed nations.

There was poor loading of items in the social influence construct thereby decreasing their reliability and validity, suggesting that they were probably measuring different topics. Future studies might require more understanding of the scales, for example, looking at affective components such as thrill, and comfort.

A further study could investigate behavioural adaptations by the drivers' as possible reasons for the findings in this study. According to Saad & Elslande (2012), the acceptance of support systems by drivers' is dependent on road situations and the driver population. For example drivers are prone to ignore the speed warnings by the ISA in areas where speed is a "norm" or in surrounding traffic or areas when they feel under pressure from other drivers. Also the propensity to drive faster or slower than the surrounding traffic could play a role in the acceptance of the ISA system. Here drivers had short-time experiences with the ISA system, thus limiting the effects of any longer-term adaptation.

Chapter 10: General discussion and conclusions

10.1 Overview

Anecdotal evidence suggest that drivers' who work in companies with strong safety culture have different psychological process that influences their choice of driving speed in work and private vehicles. Given the lack of theory driven speeding interventions, this research was intended to investigate and understand the psychosocial determinants of driver compliance with the speed limit in their work, and private settings, in the hope of developing effective speed management tools.

The previous chapters of the thesis have presented the research program, which addressed the following research aims:

1. To understand the psychosocial determinants of speeding behaviour of drivers' in their work and private vehicles.
2. To develop and evaluate the effectiveness of speed limit compliance interventions on drivers' speed choice in their private vehicles.

This thesis used a multi-methods approach of observations, and experiments, analysed both qualitatively and quantitatively, all of which were strongly connected. Each successive study was informed by the prior stages within the research work. Through focus groups discussions, Study 1 explored drivers' salient beliefs underpinning speeding. Specific emphasis was placed on their key behavioural, normative, and control beliefs. Study 2 was a prospective, cross-sectional, quantitative survey designed to examine the psychosocial determinants of speeding in drivers' work and private vehicles. The basic TPB model was used as a framework. Study 3 tested and evaluated the short-term effectiveness of an advisory Intelligent Speed Assistant (ISA) system and a Speed Awareness Course (SAC) on drivers' speed choice. Study 4 was a prospective, cross-sectional, quantitative study on the acceptance of the ISA system.

This final chapter draws together, and integrates the main findings obtained across all four studies conducted during this research. It begins with the review of key findings which are then discussed in relation to the research questions. This discussion is followed by the safety, theoretical, and practical implications emerging from, and associated with, the research. Finally, the strengths and limitations of the research and directions for future research are presented.

10.2 Summary of findings

This section will summarise the key research findings for each study.

10.2.1 Study 1

Study 1 was a qualitative elicitation study, conducted to elicit salient beliefs relating to speeding in Nigeria. It involved 13 participants across 3 focus group discussions. Findings revealed that drivers' held beliefs that speed violation, particularly excessive speeding, was a dangerous behaviour, and that most important others would not approve. In contrast, reduced journey times, emergencies (mostly for security purposes), and driving on good and wide roads would increase their likelihood of speeding. Engineering interventions such as speed humps and driving on congested roads would discourage them from speeding, whilst empty and "good" roads facilitated speeding. Therefore, the above findings implied that issues of social pressures should be considered when developing speeding interventions in developing countries such as Nigeria.

10.2.2 Study 2

Study 2 described a prospective survey conducted to examine the predictors of speeding intentions and self-reported behaviour in drivers' work and private settings. It demonstrated that the TPB was a useful framework for predicting and evaluating drivers' intentions and propensity to comply with the speed limit. The study also sought to investigate the relationship between driver's TPB variables and their observed behaviour in their private vehicles. The study involved 2 phases of data collection of Time 1 (measured before the intervention) and Time 2 (measured after the interventions). During which drivers' were exposed to an advisory ISA, and undertook a speed awareness course. Findings showed the following.

Prediction of intention to speed and self-reported behaviour

At Time 1: Attitude explained 12% and 24% of variance in Intention to speed in work and private vehicles respectively. Subjective Norm and Perceived Behavioural Control (PBC) did not make any significant contribution. Further, at Time 1, Intention and PBC were found to explain 44% of variance in self-reported behaviour in private vehicles. Intention and PBC did not significantly predict self-reported behaviour in the work vehicle.

At Time 2: Insufficient power for a regression analysis for time 2 data.

Comparison of variables between work and private settings

At Time 1: The results showed that participants were relatively more likely to have favourable Attitudes, more support from important others, perceived greater control of the behaviour, have stronger intentions, and more self-reported behaviour in a work vehicle than in a private vehicle.

At Time 2: The results revealed a low, but significant difference in participants' PBC, Intentions and Self-reported Behaviour between work and private settings. Participants' at Time 2 were more likely to have more positive Intentions, greater perceived control of their behaviour and actual performance of the behaviour in a work vehicle than in their private vehicle. However, there were no significant differences identified for Attitudes and Subjective Norm in work and private vehicles.

Evaluation of impact of intervention in work and private settings

The results did not show any significant differences within work or private vehicles. For example, drivers' cognitions levels in work settings remained the same even after the intervention. The same applied to their cognition levels in private settings.

The relationship between TPB variables and objectively measured speeding behaviour in private settings

Results suggest that driver's Intention and PBC were negatively correlated with their observed behaviour. Also, the median split of the TPB variables revealed that low Intenders were more likely to engage in speed limit violation compared to high Intenders.

10.2.3 Study 3

Study 3 describes data collected from on-road field trials examining the short-term effectiveness of an advisory Intelligent Speed Assistant (ISA) system and a Speed Awareness Course (SAC) on drivers speed choice. Data was collected in three two-week field period, with each drive lasting for approximately 50 minutes. The drives followed a Baseline – Intervention design. Participants first had a baseline drive (without any intervention) and a counterbalanced drive between ISA and SAC. Drives were on a selected route with 50, 60 and 80 km/h speed zones. Findings, relating to the impact of ISA and SAC, suggest that both interventions were able to reshape the speed distribution. Also, both countermeasures, were effective in reducing drivers' mean speed, speed variability and curtailing speeds at the high end of the speed distribution across all speed zones. Further, both ISA and SAC significantly reduced the percentage distance of speeding above the speed limit. Finally, using the Power Model, it was estimated that the interventions would reduce serious-injury crashes by about 33%, and fatal crashes from about 47% across all speed limits.

10.2.4 Study 4

Having demonstrated that experience with an advisory/warning ISA system prompted a change in drivers' speed choice, Study 4 went on to examine the acceptability of the ISA, using the Unified Theory of Acceptance and Use of Technology (UTAUT) model as the conceptual framework. The study involved 2 phases of data collection: Time 1 (measured before the use of ISA, n = 20) and Time 2 (measured after the use of ISA, n = 20).

Findings, revealed that the predictive power of the UTAUT model was only significant at Time 2, explaining 35.5% of the variance in intention to use. Further, analysis examining changes in acceptance level over time showed a significant decrease in Performance Expectancy and Social Influence. Effort Expectancy and Behavioural Intention did not change.

The next sections of this chapter discuss the key findings in relation to each of the seven research questions.

10.3 Synthesis of research findings

This section will synthesise the research findings across the four studies, and will be structured according to the seven questions underpinning the program of research. In addition, the findings will be synthesized relative to available literature. It is noteworthy that the participants in the research were volunteers, and worked in a company with strong safety culture. Data from participants included, their personal characteristics (age, experience, mileage), Attitudes towards speeding in work and private vehicles, Self-reported and objectively measured driving behaviours. Therefore, it is possible that the participants may have been non-speeders in general, and may have underreported speeding behaviours and biased in the observed behaviour.

10.3.1 Research question one

"What are the underlying beliefs towards speeding among Nigerian drivers?"

One of the objectives of this thesis was to investigate the salient behavioural, normative, and control beliefs of Nigerian drivers towards their own speeding behaviour (Chapter 6). The importance of eliciting such beliefs is vital, because not everyone shares similar thoughts and feelings about a behavioural phenomenon such as speeding. People's beliefs differ and appear to be affected by personal and environmental factors (Curtis et al, 2010). The findings here indicated that drivers' have a variety of positive and negative behavioural beliefs towards speeding. For example, the finding of reduced journey time/time saving, was found to be the most salient beliefs regarding the advantage of speeding. This finding is similar to those of others in this context (e.g. Elliot et al., 2005; Abdul et al., 2012; and Lewis et al., 2013). It is also well established in literature that drivers overestimate the travel time savings from driving fast (Ellison & Greaves, 2015). The belief of speeding as a way of saving time in times of emergencies (life-threatening or very serious medical conditions), and security threats (civil disorders, attacks from miscreant or arm robbers), is a first in elicitation studies. Personal and environmental factors such as those mentioned above are common in developing nations such as Nigeria, and could be an important reason for why Nigerian drivers consider speeding during attitude formation.

Another important finding raised by the elicitation study is concerned with the content of normative beliefs. The results show that people perceive that while family members and female friends do not approve of the behaviour, male friends and peers support and approve of speeding. These results are consistent with previous research (Horvath et al., 2012; Elliot et al., 2005). According to Downs & Hausenblas (2005), most frequently normative influences were from family and friends, and people mostly value the opinions of their spouse/partners and their friends, followed by the judgement of other family members.

The most common elicited control beliefs inhibiting speeding were roads with speed humps, and driving with family members as passengers. Good roads (roads that are wide, straight and lack potholes) and roads with minimal traffic were the most salient facilitating beliefs to speeding. The fact that good road networks is considered a facilitator to speeding, is associated with the poor road infrastructure in Nigeria. The deplorable state of roads is a common sight across the country, so that when drivers' are faced with any semblance of good roads, they may wish to speed to catch up for lost time, trying to get from one spot to another.

With the belief base of the TPB (Ajzen & Fishbein, 1980; Ajzen, 1991) used as framework, this study has expanded on past research (e.g. Elliot et al., 2005, Abdul et al., 2012, Lewis et al., 2013) providing insights into an array of beliefs influencing speeding behaviour, with a particular focus on the beliefs and strategies relevant to Nigerian drivers. The findings from Study 1, were adapted and incorporated into the Speed Awareness Course (SAC), and used to prompt discussions during the interactive sessions.

10.3.2 Research question two

"*What are the predictors of drivers' intention to comply with speed limits and self-reported compliance with the speed limit in their work and private vehicles?"*

Predicting Intention

In this thesis, the TPB was used to predict intentions to comply with the speed limit in a work and private vehicle, and over two time periods (before and after the interventions) (section 7.4.1). Overall, the TPB explained 12 to 59% of the variance in intentions (when analysed cross-sectionally at each survey phase), which compares favourably with a review of the TPB, which estimate that the basic constructs of the TPB explains 39% of the variance in intentions (Armitage & Conner, 2001).

Before the interventions, the theory explained 12 and 24% of the variance in intention to speed limit compliance in a work and private vehicle respectively. This is similar to results presented by Newnam et al. (2004) (work: 16% and private: 27%). Due to the small sample size used for the interventions, the model was unable to predict Intentions and self-reported behaviour. This finding will suggest a better utility of the TPB in prediction in a private setting than in a fleet setting. This may be because drivers have more freedom in their personal settings to express beliefs and attitudes which they are unable to do in a working environment, due to the particular safety regimes in place at work.

Attitude emerged as the only significant predictor and strongest correlate with intentions in both work and private vehicles (Work; β =0.33: Private; β =0.50), which is similar to past studies (Newnam et al., 2004). The correlation at this phase was similar across both work and private vehicles. This result was supported by the critical beliefs analyses in Study 1, in particular “Speeding as the cause of accidents and fatalities” (a behavioural belief). This finding suggests that Attitudes are one of the most important determinants of speed choice, and is consistent with prior studies that have documented the role of attitudes and behavioural beliefs in predicting Intentions with regards to speed choice (Parker et al., 1992a; Newnam et al., 2004; Elliot et al., 2005; Chorlton, 2007). In terms of other determinants of intention as hypothesised by the TPB, of note, Subjective Norm was not significant within any setting in the prediction. This is uncommon, as past studies (Newnam et al., 2004; Abdul Hanan, 2014, Armitage & Conner, 2001) have all found the construct to be a weak predictor of intention.

The findings would suggest that, in this context future speeding interventions should aim at modifying drivers’ Attitudes, as it appears to be the strongest predictor of Intention to perform the behaviour. Future interventions in this context should aim at modifying those salient behavioural beliefs drivers hold towards speed limit compliance.

Predicting self-reported behaviour

The TPB was used to predict self-reported speed behaviour in both work and private vehicle, and over a two-time period. The model was only able to predict behaviour at **Time 1**, and in a private vehicle. Intention (β=0.62) and PBC (β=-0.19) accounted for 44% of the variance in Self-reported behaviour. This finding is similar to past research (Elliott et al., 2004; Stead et al., 2005; Abdul Hanan 2014), but, somewhat inconsistent, when measures were taken prospectively, hence difficult to make any clear conclusions. The only possible explanation is that at Time 1 the model was better operationalised in the private vehicle setting as already discussed above, while the small sample size at **Time 2** did not allow for prediction of self-reported behaviour.

10.3.3 Research question three

"Will the differences in drivers' intention to speed limit compliance in work and private vehicle reflect the differences in their Attitudes, Subjective Norm and Perceived Behavioural Control?"

Although, participants reported relatively high Intentions to comply with speed limits in both their work and private vehicles, significant difference was found between the two settings at only Time 2 **Time 2**: Z (19) = 2.232 p= 0.026)[11]. Results revealed that drivers reported a higher Intention to comply with speed limits in their work vehicle after the Interventions (**Time 2**, M=5.0), than a private vehicle (**Time 2**, M=4.0).

Difference was also reflected in the determinants of intentions to comply with speed limits. At **Time 1,** significant differences were identified for Attitudes, and Perceived Behavioural Control between a work and personal vehicle. The results show that drivers' were relatively more likely to have favourable Attitudes, and perceived greater control of the behaviour in their work vehicle than in private vehicles. Thus, it is suggested that these components account for some of the differences observed in the reported higher intention to comply with speed limits in a work vehicle.

At **Time 2**, no significant differences were identified for Attitudes and Subjective Norm, for a work and personal vehicle. However, a small but significant difference was found between a work and personal vehicle for PBC. The results revealed that drivers were relatively more likely to perceive greater control of their speeding behaviour in their work vehicle than in a private vehicle. It is likely that drivers' think that in the work vehicle they are less affected by family and others and have more right to resist pressure from other

[11] This comparison is when analysed cross-sectionally at each survey phase.

drivers. The PBC may have accounted for the differences in reported higher intention to comply with speed limits in a work vehicle.

These findings suggest, that the strong safety culture within the participant's organisation, had more emphasis on work safety and has not completely influenced drivers' personal safety. Thus, there is a need to synchronise work and private safety by internalising company safety policies and messages. Drivers' should be supported rather than be pressured to comply with speed limits.

10.3.4 Research question four

"Will the combined interventions have any effect on drivers' cognitive variables?"

The TPB was used to evaluate the effects of the interventions on the psycho-social determinants of speeding on which the model is based on (refer to section 7.4.3). It was hypothesised that the interventions would positively modify the determinants of speeding behaviour. Scores on the main TPB constructs were compared between baseline and the follow-up survey, for the 20 drivers' who participated in the experimental phase.

Less encouragingly, but not surprisingly, there was no evidence that the interventions brought any substantial changes to any of the TPB constructs. A possible explanation is that, given participants reported extremely favourable cognitions towards complying with speed limits prior to undergoing the interventions, there was a ceiling effect, thus limiting the scope for the interventions to increase participants scores above baseline levels.

The limited effect of the interventions on drivers beliefs and cognitions may in part, be due to the intensity in the delivery of the interventions (participants were exposed to the interventions over a short period of time). This finding is similar to the study by Elliot & Armitage (2009), who found potential ceiling effects in their measured behavioural and normative beliefs and other previous studies that had limiting effects on the TPB-based interventions on speeding behaviour (e.g. Parker et al., 1996; Stead et al., 2005). In their review, Hardeman et al. (2002), conclude that TPB- based' interventions hardly produce significant changes in Attitude, Subjective Norm and PBC, and thus do not permit inferences about potential impacts on intentions or behaviour that would accrue from generating substantial changes in the respective predictors (either individually or in combination (Fife-Schaw et al., 2007).

10.3.5 Research question five

"Will there be any relationships between TPB variables and the objectively measured speeding behaviour?"

This research question sought to identify the relationship between TPB constructs and objectively measured speeding behaviour. This was evaluated using associations by correlations, and a median split of driver's TPB variables compared to the percentage distance driven at 1km/h or more on the 50km/h speed zone, in their private vehicles and at baseline. Results suggest that higher levels of driver's Intentions toward speed limit compliance and strong Perceived Behavioural Control are correlated with lower levels of objectively measured speeding behaviour (i.e. less compliance with the speed limit). Dichotomous groups of low Intenders and high Intenders had significant differences in their observed speed, with the former more likely to engage in speed limit violations (medians PDAS: low Intenders M=70.9%; high Intenders M= 62.3%).

10.3.6 Research question six

"To what extent will the interventions affect drivers' choice of speed?"

The fifth research question sought to evaluate the impact of the interventions on objectively measured drivers' speeding behaviour. This was partly answered in study 3 which involved developing and testing the efficacy of a TPB-based Speed Awareness course (SAC), and Advisory Intelligent Speed Assistance system (ISA) on drivers' speed choice (see Chapter 8).

These impacts were assessed based on the changes in speed distribution, mean speed, speed variability, 85th percentile speed, percentage distance travelled above the speed limit and the estimated safety benefits in terms of crash reductions.

Speed distribution

The assumption was that, both interventions would reshape drivers' speed distribution across all speed zones.

The findings showed that both interventions significantly translated drivers speed distribution across all speed zones, by moving the speed curve to the left (i.e. away from the baseline levels and speed limit). High-end speeding was curtailed by both interventions. However, very minimal changes were observed in the low-end speed (speeds lower than the speed limits). These findings are similar to previous studies (e.g. Lai et al., 2012b; Regan et al., 2006a; Hou et al., 2012). Comparatively, the ISA intervention appears to have resulted in the lowest speed distribution across the different speed zones.

The findings also show that, compared with the general population drivers, participants in the study were slightly more conservative in their speed choice in the 60km/h and 80km/h speed zones, with the plausible explanation being their work training and related safety culture. However, in the 50km/h speed zone, general population drivers had lower speed choice which could be related to the different days of data collection.

These finding suggest that not only were the interventions able to reduce maximum speeds and speed violations but also they did not encourage participants to gain time (from perceived lost time) by attempting to drive closer to the speed limits (i.e. no negative behavioural adaptation was observed).

Mean speed

Results from Study 3 (reported in Chapter 8) indicate general high reductions in mean speed, from the interventions, and across the different speed limits zones. For the Advisory ISA, this decrease was in the order of 15 km/h, and with the Speed Awareness course just over 10 km/h. The urban arterial speed zone of 60 km/h saw the maximum reduction in mean speed of 21.6%.

The findings (mean speed reductions) from this study are somewhat higher than pervious ISA studies (Ghadiri et al., 2013; Agerholm et al., 2008a; Brookhuis & de Waard, 1999), and similar speed education studies (Hou et al., 2012; Siregar, 2018). The differences in circumstances (method of delivery, duration of interventions, and sample populations) could be a plausible explanation. For example, the baseline speeds of participants in this study were rather high, especially in the 50 and 60 km/h speed zones, and could have provided a greater opportunity for the ISA system to affect their speeds given, that the drivers were previously at higher speeds.

Speed variability

As discussed in the literature review section and Chapter 8, the amount of speed variation has a direct influence on crash rate. This study showed a decrease in speed variation with both ISA and SAC. Both interventions were comparable in reducing speed variance by up to 4 km/h. The 60 km/h speed zone had the highest variability in the baseline (likely due to the sharp curves and bends that required decreases and increases in speed), resulting in the biggest reductions by the interventions. In general the results reflect those of previous advisory ISA studies.

85th percentile speed

Previous behavioural studies have used the 85th percentile speed as an indicator to measure impacts of speeding interventions. As predicted, both ISA and SAC were effective in reducing high end speeds. The reductions were up to 21% for the ISA and

15% for the SAC, across all speed limits. These findings are consistent with past studies that found the advisory ISA to be particularly effective in reducing high-end speed.

Overall, the reductions in the 85th percentile speeds is a good indicator of the effectiveness of the interventions and is positive for safety.

Percentage distance travelled above the speed limit (PDAS)

The PDAS has been described in the literature as a better indicator of the effectiveness of interventions, rather than just overall speed reductions. It tends to minimise bias from low speed during congestion, intersections and other stops during the drive.

As discussed in Chapter 8, the interventions significantly reduced speed violations across all speed zones. ISA recorded a 100% reduction in distance travelled above the speed limit in both 60 and 80km/h speed zones. These findings, are in line with those of Lahrmann et al. (2012) and Lai et al. (2012) who in their studies found ISA to reduce speed violation by up to 44 and 70.5% respectively.

The findings demonstrate that a simple ISA application and a theory-based speed awareness course have the ability to reduce speed limit violation in Nigeria. However, these findings should be treated with caution, as reductions could be from “novelty” effects[12], presumably due to the fact that the trials was a short- term trial, a thus there is a need for longer-term measurements.

Road safety estimation

Nilsson’s (1982) Power Model, proposes a relationships between changes in traffic speed, the number of crashes and the severity of injuries. As part of the research objectives, the safety gains from the interventions were estimated (refer to section 8.5). Estimates from the Power Model found large safety benefits from the interventions. It was estimated that ISA would induce a 44 and 59% reduction in serious-injury and fatal crashes, respectively, across all speed zones. Estimated reductions in serious-injury and fatal crashes from TPB–based speed awareness course were in the order of 33 and 47%, respectively, across all speed zone.

These estimations are comparatively higher than previous studies with advisory ISA which have found reductions in the range of 6-23%. One would expect underestimation of the impacts in Nigeria, considering the existing exponents of the Power Model were calibrated against data from high income countries, which have better safety infrastructures and policies. Thus, its application to data from Nigeria, a low-income country, with a poor safety culture should result in lower estimates (i.e. the Power model

[12] Novelty effect here is the tendency for performance to initially improve when new technology or treatment are introduced (Martin et al., 2016).

is likely to have lower exponents in this context). However, the large effects in this study are due to the high speeding in the baseline.

10.3.7 Research question seven

"What are the determinants of intention to use an ISA system?"

To answer this research question, the Unified Theory of Acceptance and Use of Technology (UTAUT) was used in Study 4, to determine the psychosocial predictors of Intention to use the Advisory ISA, before and after treatment (See section 9.4.1). The UTAUT model was only able explain the variance of Intention to use after drivers' had experienced the ISA. Overall, the model explained 35.5% of the variance, with Performance Expectancy as the only significant predictor of Intention to use. This suggests that, participants held some preconceptions about ISA prior to usage (they had no prior experience), hence the inability of the model to successfully predict intention at Time 1. After experiencing the advisory ISA, Performance Expectancy (their level of belief or satisfaction from the gains of using the system) with ISA became the determinant of their Intention to future usage.

This finding is very similar to past studies that have found Performance Expectancy as the main predictor of Intention to use technology (Adell, 2009; Madigan et al., 2016)

The findings from this study provide useful information regarding perceived gains and drawbacks associated with driving with the ISA, and beliefs that could form the basis of a structured implementation campaign. However, the results from this study should be treated with caution, due to the small sample size, and lack of extensive interaction and experience with the system.

10.3.8 Research question eight

"Are there differences in driver's acceptability of the ISA system after usage?"

This research question sought to evaluate acceptability levels before and after usage of the ISA (section 9.4.2). Surprisingly, acceptability scores relating to Performance Expectancy and Social Influence, though still favourable, decreased significantly after experience with the ISA system. By inference, participants were likely not impressed with the system even though they found it useful. This may be as a result of preconceived notions. However, their Effort Expectancy and Behavioural Intention remained the same over the study period.

Again, the findings can be use as framework for future implementation of ISA in Nigeria.

10.4 Implications of research findings

10.4.1 Theoretical implications

The findings from this thesis provides some insights in the capacity of the Theory of Planned Behaviour as a suitable framework for understanding driver behaviour, and particularly driver compliance with the speed limit in work and personal vehicles. To the best of candidate’s knowledge, there has been only one TPB-based study to have investigated the factors underpinning drivers’ compliance with the speed limit in their work and private vehicle (Newnam et al., 2004), given that most studies focus on the general population drivers. Thus, this research provides valuable contribution to available literature on drivers’ speeding behaviour within a specific context; namely, speeding behaviour of drivers who work in a company with a strong safety culture in their work and private setting.

In terms of the applicability of the TPB in work and private settings, this model showed better prediction of Intention to comply with speed limits in their private rather than work vehicles. This finding suggests that the diagnostic utility of the model is better operationalised for studies investigating general driving behaviour (Newnam, et al., 2004), where drivers’ have a higher degree of freedom to express beliefs and attitudes which they are unable to in a working environment.

The diagnostic utility of the model that was demonstrated in the present study is important, because it provides support for the argument that some of the relationships proposed by the TPB are causal (i.e. Attitudes > Intentions > Behaviour). Although the present study did not provide evidence that other relationships are causal (e.g. Subjective Norm > Intention > Behaviour), it does not necessarily rebut the model. However, it highlights need to extend the model as already been proposed by previous studies in this context (Conner & Armitage, 1998; Pelsmacker & Janssens, 2007; Elliot & Thomson, 2010; Ketphat et al., 2013). These include either expanding current constructs (e.g. the need to expand Subjective Norm by including injunctive and descriptive norm[13]) or by additional variables such as habits, anticipated regrets etc.

This study also demonstrates the utility of the TPB as a framework for modifying driving behaviour. The findings suggest that the Speed Awareness Course significantly reduced speed limit violation of test drivers’. Although, there is no clear evidence of the effect of the course on drivers’ cognitions. According to Fife-Schaw et al. (2007), the latter finding is not unusual, as changes in cognition are difficult to achieve.

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[13] Injunctive Norm: Concerns the moral aspect of whether behaviour is appropriate or not
Descriptive Norm: refers to individuals’ perception of what is commonly done by others.

The current study was able to identify some association of TPB constructs and objectively measured speeding behaviour. Findings suggest that that higher levels of driver's Intentions toward speed limit compliance and strong Perceived Behavioural Control are correlated with lower levels of objectively measured speeding behaviour. Also, the results suggest that participants with low intention to speed are less likely to engage in speed limit violation when compared with those with higher Intention to speed.

The present study has to some extent gone further than most past studies on the TPB, which have only tested the predictive ability of the model.

The elicitation study identified very salient beliefs held by Nigerian drivers with respect to speeding behaviour, which is slightly different from findings in high-income countries. Therefore, this study can be used to inform future research directions.

In terms of increasing the understanding of the use of UTAUT, the findings from this study provide some insights into the factors that underpin the acceptance of Advisory ISA in the Nigerian context, and suggest the model can be adapted in driver behaviour studies.

10.4.2 Road safety implications

This thesis has a number of important applied implications for speed limit compliance interventions, and general road safety.

The elicitation study (Study 1) identified salient beliefs held by drivers' that could be used in the design of speeding interventions in Nigeria. For instance, future speed limit interventions can incorporate strategies that target drivers' beliefs that speeding on roads with less traffic is safe (highlighting the unpredictability of circumstances). Strategies that highlight the consequences of speeding, focussing on vulnerable road users and children will be helpful. Finally, emphasising how the society perceives a speeding driver is likely to be effective. Interventions could include speed awareness courses for intending and offending drivers, and the use of persuasive media campaign messages.

Additionally, this research has shown that drivers' attitudes constitutes the most important antecedents of their intentions to comply with the speed limits, when using their work and personal vehicles. It can be recommended that behavioural interventions aimed at reducing speed limit violation among Nigerian drivers, should target their attitudes (drivers' positive or negative evaluation to performing the behaviour).

For instance, campaigns strengthening positive beliefs and confirming the consequences of speeding can provide useful and stable bases for interventions. Persuasive strategies such as highlighting the losses in terms of grief and properties they can cause other road users and children, can help translate their held beliefs into favourable behaviour.

One key finding from this study is that, the organisational guidance on safety culture[14] does not influence employee's personal beliefs and behaviour. Drivers' in this study reported significantly less favourable cognitions and behaviour towards speed limit compliance in their private setting, compared with the work setting. This finding is not surprising as most organisations emphasise more on work safety, and only support those initiatives and interventions that serve their commercial interests (Mohan & Roberts, 2001). Thus, it is important to establish how organisations can bring the work and private attitudes of their employees together, and ensure their internal promotion and training on safety is transferred to the general population.

Possible interventions may include options for organisations to internalise speed limit compliance messages and training for drivers, rather than emphasising too much on work safety. For instance, organisational speed limit compliance campaigns should be designed to encourage reinforcement of speed limit compliance as 'the right thing to do'. Companies should encourage their drivers to imbibe safety as a way of life through continuous support, and provide rewards for compliance, rather than putting employees under undue pressures. Speed limit compliance enforcement should be driven by positive sanctions rather than punishments (Baldwin, 1971). Drivers should be given positive attention, by letting them know when they do well (meet speed limit compliance targets) and be encouraged to keep complying This positive attention can include specific verbal praise during tool box meetings, and incentives for compliance, perhaps also encouraging colleagues to support each other.

The Global Road Safety Partnership (GRSP: https://www.grsproadsafety.org/) is an example of an initiative that believes that a partnership between the private sector — in particular, multinationals and large companies, non-governmental organisations, and governments in developing countries — can deliver regarding improvements in road safety in these countries. This project was established by the World Bank in 1999 and premised on an understanding, by all sectors that road safety has far reaching effects on business, markets, consumers and society at large. Therefore, all of society must contribute to the solution. Most governments in Low and Middle income countries have limited funding for road safety interventions and competing priorities, thus, a partnership with multinationals (those with a strong safety cultures) can assist through capacity

[14] Organisation Safety Culture: the assembly of underlying assumptions, beliefs values and attitudes shared by members of an organisation, which interact with an organisation's structures and systems and the broader contextual setting to result in those external, readily-visible, practices that influence safety'' (Edward et al., 2013)

building, knowledge sharing, advocacy and campaign delivery, serving as a way of applying the safety culture perspective to the general population of drivers'.

There are perhaps some challenges in applying the multinational traffic safety culture of organisation to an entire population of road users, since bespoke schemes for organisations may not be applicable to road traffic culture of different countries (Nævestad & Bjørnskau, 2012). However, these basic guidelines can still affect road traffic safety of these Low-and Middle-Income countries by changing the behaviour and safety culture of fleet drivers, while also collaborating with government in terms of setting road safety policies, sharing knowledge in the development of driver training and licensing procedures, training "trainers" and traffic management agencies, supporting road safety research, and support in the development of traffic safety campaigns that are sensitive to the socio-cultural context of their host nations.

The findings from this research also suggest that, as long as the driver chooses to use the advisory ISA application such as that used here, there is some indication of reductions in speed limit violations. A number of key factors are proposed for encouraging adoption of systems such as ISA. Firstly, considering the "limited" resources available for road safety interventions in Nigeria, and most developing nations, it will be sensible to focus more on individually tailored cost effective solutions, such as the smartphone-based advisory ISA application used in this thesis.

Secondly, it is very likely that most drivers in low-income countries like Nigeria lack knowledge of legal speed limits. Although, theoretical and practical road tests are a legal requirement for obtaining a driver's license, it's common knowledge that most Nigerians acquire their licence without undergoing these tests. In addition, most Nigerian roads either do not have speed limit signage or available ones are either defaced or worn out. Therefore, if steadily updated this type of device will provide a user-friendly and effective speed limit advisory system.

Finally, Nigeria does not currently have a speed limit police enforcement or safety officer procedure in place. Thus, a smartphone-based speed advisory application will serve as a social cost-effective speed management tool. This type of phone-based application is mostly free, and with the steady increase in the use of smartphones and mobile internet by Nigerians, such an intervention could be very effective.

Findings from the acceptance study have also shown a high level of acceptability by the participants, and, therefore, useful information regarding perceived gains from using the system could be adapted into future implementations plans. This can involve information-based campaigns to promote favourable attitudes towards the system (Chorlton, 2007).

The Speed Awareness Course (SAC) used in this research, showed a significant effect on reduction of speed violation, even though evaluation of the effect was done over a short time. Therefore, further evaluation research would be useful to establish the medium and long-term effects of such a course. An evaluation of the national speed awareness course in the UK has shown that the effects of such a course appears to persist over time, with impacts still visible up to three years following initial participation (Ipsos Mori et al., 2018). Following wider consultations with stakeholders and road safety experts, the above recommendations could be incorporated into existing national driver training curricula, and appropriate policies put in place for suitable implementations. Such training could be done as part of the licencing process, and under strict implementations.

10.5 Limitations of the research

Caution is required in the interpretation of the findings of this research as the following limitations were present in the study.

1. Participants' high baseline levels of self-reported TPB constructs and any prior knowledge of speeding information might have influenced their responses.
2. There may be issues related to the measurement used, such as the self-reported data, and participants may have not answered truthfully, thus limiting the generalisability of the results.
3. Factors such as limited time and budget constraints prevented achieving a more ideal sample size for the study.
4. Though statistically powerful, analyses of the data has not taken into account uncontrolled variables that may have influenced drivers' choice of speed, over the entire study. Example of such variables include: drivers' emotional state, differences in traffic condition, road geometry, etc. As with all on-road studies, participants experienced varying traffic scenarios, even though they all drove on the same route. On road studies measure actual behaviour in contrast to other controlled and repeatable techniques such as driving simulator based studies. This limitation was partly compensated by conducting experiments only during weekends in more or less similar time slots.

10.6 Future research

ISA research has already been done extensively in high-income countries with estimated safety benefits, therefore, there is need to focus future studies in developing nations which seem to have a bulk of world road safety crashes and fatalities.

The participants demonstrated distinctively different speeding behaviour between the baseline and when the interventions were activated. This is could be considered a novelty effect (i.e. the participants were experimenting to find out how the ISA systems worked or just practicing knowledge from the Speed Awareness Course), rather than the participant intending to break the speed limit. This effect may be presumably due to the fact that participants trials were short-termed (just a single drive). For example, past studies show that it can take up to six months for a new behaviour such as the full adoption of a new technology, to become habits (Prochaska & DiClemente, 1982). In that time, social pressures or trends that drive initial use may wear off over time, or unforeseen issues such as scalability or maintenance may arise. Thus, there is a need for future studies to investigate the longer-term effect of the interventions on a driver's choice of speed.

To investigate the full potential and applicability of the smartphone-based ISA, future research should involve large-scale real road investigations to validate the operations and impacts of such systems on real-world speeding behaviour. Also adaptation and acceptability of the technology can be investigated by using a broader demographic representations.

Also future research should attempt to involve organisations that do not have strong safety culture for their drivers (e.g. companies that deal with less hazardous or expensive materials). Such a study will not only provide more insights regarding the differences in attitudes and behaviour between organisations with strong and those with lenient safety cultures, but would also help to explain the variance in the behaviour of drivers in the work and private settings.

10.7 Final conclusion

Through the use of a well-established model, namely the Theory of Planned Behaviour (TPB), this research programme investigated the psychological processes that influence drivers' choice of speed when driving a work and private vehicle, focussing on drivers who work in a company with a strong safety culture. Furthermore, the thesis also tested and evaluated the effect of a smartphone advisory Intelligent Speed Assistance application, and a TPB-based Speed Awareness course (SAC) on drivers' speeding behaviour.

The studies conducted were able to successfully present differences in the cognitive process that predict drivers' speed choice in their work and private vehicles. Driver's attitude appeared to be the strongest predictor of their intention to comply with speed limits. The ISA and SAC interventions resulted in a significant increase in speed limit compliance. However, the short-term experience with the system did not result in any significant improvement in drivers cognitions. Acceptability ratings surrounding ISA, suggested that drivers' Performance Expectancy was the main predictor of Intention to use.

The thesis supports the applicability of the TPB as a diagnostic tool, and guide for the development of behavioural change interventions. The findings also provides some insights into tackling speeding in Nigeria through a cost-effective technological and theory-driven education campaign. Together, the approaches provides potentials for improvement of fleet safety and application in general road traffic safety and performance.

This research has been focussed on understanding and modifying driver speeding attitudes and behaviours, and while there might continue to be disputes over which factors are responsible for drivers behaviours, or which interventions offer the best cost-benefit ratio for improving road safety, there is currently no dispute regarding the overall approach to take when addressing the issue of 1.3 million annual global fatalities on the roads. A holistic approach involving shared responsibility by road users, vehicle manufacturers, road safety managers, and government agencies seem the best fit.

While current evidence suggests that most developing nations lack the political will, expertise, and funding for road safety interventions. There exist some positive indication coming from initiatives such as the Global Road Safety Partnership (GRSP) which aims to support developing nations towards improving road safety. It might be difficult for developing nations to successfully replicate developed nations road safety strategies as local circumstances differ. However, the principles of successful strategies can be learned and adapted to local conditions and context. This will involve investment in local capacity building and shared responsibilities that involve both public and private sector in the development and implementation of evidence-based action plans.

Road safety enforcement and management in Nigeria and most developing nations continue to be focused on promoting safe driving practices through a system of negative enforcement such as fines and loss of jobs. There is a need to promote and develop positive reward-based safe driving practices. This can involve adopting a multi-dimensional approach to driver safety management in organisations more broadly. Organisations and government may integrate work-related driving safety responsibilities within the roles and responsibilities of individuals within general road safety enforcement agencies, insurance agencies and organisations employing work-related drivers. This will also involve the incorporating of improvement in driver attitudes and risks perception to driver training programs (which currently only focus on improving driver skills). According to Mamo et al. (2014), this strategy will improve drivers' own value given to safety, promote beliefs in a drivers' ability to drive safely, and allow drivers to generate strategies to overcome overload of the driving task.

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Appendices

A.1 Study 1 Interview Template

Opening Questions

What do you think about speeding (speed violation and Excessive speeding for the conditions)?

Behavioural Beliefs.

- What do you believe are the advantages of speeding?
- What do you believe are the disadvantages of speeding?
- What do you like about speeding?
- What do you hate about speeding?

Normative Beliefs

1. Are there any groups or people who would approve of you exceeding the speed limit or speeding?
2. Are there any groups or people who would disapprove of you exceeding the speed limit or speeding?

Control beliefs

1. What factors or circumstances will make it easy for you to comply with speed limit or avoid speeding?
2. What factors or circumstances will make it difficult for you to comply with speed limit or avoid speeding?
3. What will stop you from exceeding the speed limit or speeding?

A.2 Attitude Survey

Researchers Initial-------- Location------------- Date------

Participants ID------------

Particpants Phone number-----------

UNIVERSITY OF LEEDS
Institute for Transport Studies (ITS)

Dear Sir,

Thank you for volunteering to participate in this survey, which is being undertaken as part of my PhD research at the Institute for Transport Studies, University of Leeds, UK. The purpose of this survey is to understand driver's attitudes and behaviours related to driving speed in their fleet and private driving.

Your responses will be treated in strictest confidence and will only be used for research purposes. All information you give is greatly appreciated.

Please remember that we are after your honest opinion and there are no right or wrong answers. Your participation is completely voluntary and should you feel concerned you have the right to stop participating at any time.

Driver Attitude and Behaviour Survey

The following survey contains questions in six sections. Please use the instructions in each individual section to guide your answers to the questions. Please respond on each question.

Section 1 – General driving history

I would first like to ask you questions about your general driving behaviour in both a work vehicle and your personal vehicle. For each vehicle please indicate your answer by circling *one* number on the right.

	Work Vehicle		Private Vehicle	
1. How often do you drive each week?	Less than a week	1	Less than a week......	1
	Once a week	2	Once a week	2
	Twice a week	3	Twice a week	3
	Three times a week ...	4	Three times a week...	4
	4-5 times a week	5	4-5 times a week.......	5
	Every day	6	Every day	6
2. How many hours a week do you drive?	0-5 hrs	1	0-5 hrs	1
	6-10 hrs	2	6-10 hrs	2
	11-15 hrs	3	11-15 hrs	3
	16-20 hrs	4	16-20 hrs	4
	21-30 hrs	5	21-30 hrs	5
	Greater than 30 hrs ...	6	Greater than 30 hrs...	6
3. How many kilometres do you usually drive in a year?	0-5000 km.............	1	0-5000 km.............	1
	5 000-10 000 km	2	5 000-10 000 km......	2
	10 000-15 000 km ...	3	10 000-15 000 km ...	3
	15 000-20 000 km ...	4	15 000-20 000 km ...	4

	20 000-30 000 km ...	5	20 000-30 000 km ...	5
	Over 30 000 km	6	Over 30 000 km......	6
4. What type of vehicle do you drive?	Car	1	Car	1
	Bus	2	Bus	2
	Pickup Truck	3	Pickup Truck	3
	Tankers	4	Tankers	4
	None	5	None	5
5. How long have you been driving a work-related vehicle for your current employer?	Less than 12 months.			1
	1-3 years			2
	4-7 years..................			3
	8-15 years			4
	12-20 years			5
	20+ years			6
6. How long have you had a Driving Licence?	Less than 12 months.			1
	1-3 years			2
	4-7 years..................			3
	8-15 years			4
	12-20 years			5
	20+ years			6
7. How old are you?	18 – 25			1
	26- 35			2
	36 – 45			3
	46- 55			4
	56 – 65			5
	65+			6

SECTION 2 - Organisational Safety Policies

I would now like to ask you some questions about your organisation's approach to safe driving. Thinking about the organisation you currently work for please indicate your answer by circling *one number in the columns to the right of each questions.*

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
8. The Company Safety Policies and regulations are very important to me?	1	2	3	4	5
9. The Company policies are determinant of my speed choice?	1	2	3	4	5
10. My choice of speed is more from fear of losing your job than for safety?	1	2	3	4	5
11. I would be happier if the company relaxed it safety policies	1	2	3	4	5

Section 3– Driving in different situations

I would now like to ask you some questions about your driving in different situations. Please read the following questions and (1) rate how often you do the following things when you are driving a work vehicle for related purposes and (2) rate how likely you are to do the same things when you are driving your personal vehicle on your own time. Indicate your answers by circling *one* number for each vehicle type on the scales labelled Never to Every Time below.

	Work Vehicle					**Personal Vehicle**				
	Every Time	Almost every time	Sometimes	Almost Never	Never	Every Time	Almost	Sometimes	Almost Never	Never
12. Exceed the speed limit by more than 10 km/h on urban roads?	1	2	3	4	5	1	2	3	4	5
13. Exceed the speed limit by more than 20 km/h on urban roads?	1	2	3	4	5	1	2	3	4	5
14. Exceed the speed limit by more than 10 km/h on highways?	1	2	3	4	5	1	2	3	4	5
15. Exceed the speed limit by more than 20 km/h on highways?	1	2	3	4	5	1	2	3	4	5
16. How often do you disregard the speed limit on a residential road?	1	2	3	4	5	1	2	3	4	5
17. How often do you disregard the speed limit on a highway?	1	2	3	4	5	1	2	3	4	5
18. Deliberately disregard the speed limit late at night or very early in the morning?	1	2	3	4	5	1	2	3	4	5
19. Find yourself travelling above the speed limit without realising you are doing it?	1	2	3	4	5	1	2	3	4	5
20. Not Knowing the speed limits of the road you driving?	1	2	3	4	5	1	2	3	4	5

Section 4 – Driving your work vehicle

Before proceeding to the following section please read the scenario below. Try to evoke a mental picture of the scene, and then answer the questions on the following pages.

You are alone in a work vehicle speeding down a residential street (built area) with cars parked down both sides. It is 4 o'clock on a fine and dry afternoon. The road has a 50 km/h speed limit. However, you are driving at 65 km/h per hour

Work Vehicle

Please indicate how strongly you agree or disagree with the following statements when driving your work vehicle, in relation to the preceding scenario and picture. Indicate your answer by circling ***one*** **number on the scale from strongly agree to strongly disagree.**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
21. Respecting the speed limit reduces the chance to get involved in a crash	1	2	3	4	5
22 Respecting the maximum speed limit makes you drive in a more relaxed way	1	2	3	4	5
23. It's OK to exceed the speed limit as long as you drive carefully.	1	2	3	4	5
24. Exceeding the speed limit would help me arrive my destination more quickly.	1	2	3	4	5
25. It's OK to exceed the speed limit as long as you don't have passengers in the vehicle.	1	2	3	4	5
26. Respecting the speed limit makes you need more time to reach Your destination.	1	2	3	4	5
27. I would favour stricter enforcement of the speed limit on all roads.	1	2	3	4	5
28. Exceeding the speed limit would make me feel excited.	1	2	3	4	5
29. The boss would think that I should speed 10 km/h over the limit.	1	2	3	4	5
30. Other work drivers would think that I should speed 10 km/h over the limit.	1	2	3	4	5
31. Family members would think that I should speed 10 km/h over the limit.	1	2	3	4	5
32. The police/ FRSC would think that I should speed 10 km/h over the limit.	1	2	3	4	5
33. The speed of the traffic around me is more important than the speed limit.	1	2	3	4	5
34. Although I sometimes speed in my work vehicle, I don't feel it's the right thing to do.	1	2	3	4	5
35. I am more likely to exceed the speed limit if I am in a hurry.	1	2	3	4	5
36. I find it difficult to keep to the speed limit if the traffic around me is going faster than the speed limit.	1	2	3	4	5
37. I find it difficult to keep to speed limits when the road is good?	1	2	3	4	5
38. I find it easy to monitor my speed while driving	1	2	3	4	5
39. I have complete control over whether I comply with the speed limit or not	1	2	3	4	5

Section 5 – Driving your Private vehicle

Before proceeding to the following section please read the scenario below. Try to evoke a mental picture of the scene, and then answer the questions on the following pages.

You are alone in a private vehicle speeding down a residential street (built area) with cars parked down both sides. It is 4 o'clock on a fine and dry afternoon. The road has a 50 km/h speed limit. However, you are driving at 65 km/h per hour

Private Vehicle

Please indicate how strongly you agree or disagree with the following statements when driving your work vehicle, in relation to the preceding scenario and picture. Indicate your answer by circling ***one* number on the scale from strongly agree to strongly disagree.**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
40. Respecting the speed limit reduces the chance to get involved in a crash.	1	2	3	4	5
41. Respecting the maximum speed limit makes you drive in a more relaxed way	1	2	3	4	5
42. It's OK to drive faster than the speed limit as long as you drive carefully.	1	2	3	4	5
43. Exceeding the speed limit would help me arrive my destination more quickly.	1	2	3	4	5
44. It's OK to exceed the speed limit as long as you don't have passengers in the vehicle.	1	2	3	4	5
45. Respecting the speed limit makes you need more time to reach your destination.	1	2	3	4	5
46. I would favour stricter enforcement of the speed limit on all roads.	1	2	3	4	5
47. Exceeding the speed limit would make me feel excited.	1	2	3	4	5
48. The boss would think that I should speed 10 km/h over the limit.	1	2	3	4	5
49. Other work drivers would think that I should speed 10 km/h over the limit.	1	2	3	4	5
50. Family members would think that I should speed 10 km/h over the limit.	1	2	3	4	5
51. The police/ FRSC would think that I should speed 10 km/h over the limit.	1	2	3	4	5
52. The speed of the traffic around me is more important than the speed limit.	1	2	3	4	5
53. Although I sometimes speed in my private vehicle, I don't feel it's the right thing to do.	1	2	3	4	5
54. I am more likely to exceed the speed limit if I am in a hurry.	1	2	3	4	5
55. I find it difficult to keep to the speed limit if the traffic around me is going faster than the speed limit.	1	2	3	4	5
56. I find it difficult to keep to speed limits when the road is good?	1	2	3	4	5
57 I find it easy to monitor my speed while driving	1	2	3	4	5
58. I have complete control over whether I comply with the speed limit or not	1	2	3	4	5

Section 6 – Future driving behaviour

We would now like to ask you some questions about your future driving, in relation to both a work vehicle and your personal vehicle. Please indicate how likely you are to do the following things in each situation by circling ***one*** **number on the scale from strongly agree to strongly disagree for each vehicle.**

	Work Vehicle					Personal Vehicle				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
59. In the future it is likely that I will often exceed the speed limit on urban roads	1	2	3	4	5	1	2	3	4	5
60. In the future it is likely that I will often exceed the speed limit on highways.	1	2	3	4	5	1	2	3	4	5
61. I intend to drive within the speed limit on urban roads	1	2	3	4	5	1	2	3	4	5
62. I intend to drive within the speed limit on highways roads	1	2	3	4	5	1	2	3	4	5

A.3 ISA Acceptance Survey

UNIVERSITY OF LEEDS
Institute for Transport Studies (ITS)

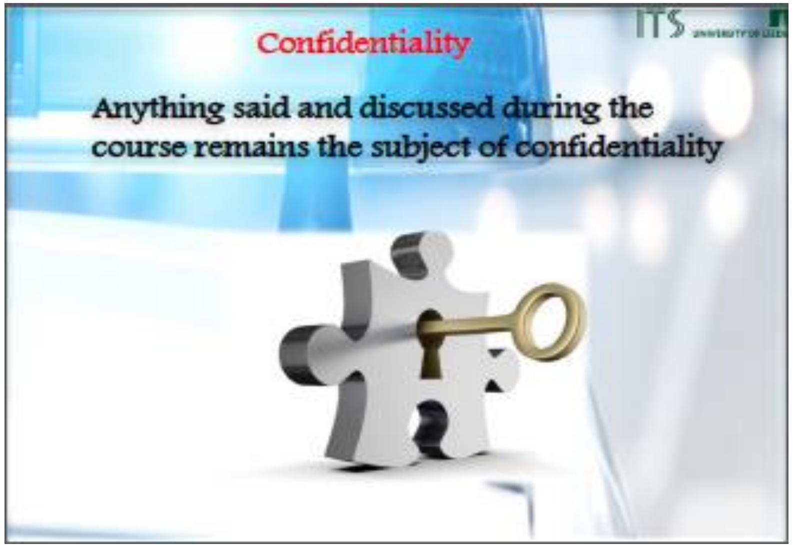
Dear Sir,

Thank you for volunteering to participate in this survey, which is being undertaken as part of my PhD research at the Institute for Transport Studies, University of Leeds, UK. **The purpose of this survey is to understand your acceptance of the Speed Advisory /warning application.** Your responses will be treated in strictest confidence and will only be used for research purposes. All information you give is greatly appreciated. Please remember that we are after your honest opinion and there are no right or wrong answers. Your participation is completely voluntary and should you feel concerned you have the right to stop participating at any time.

DRIVER SPEED ADVISORY /WARNING APPLICATION ACCEPTANCE SURVEY

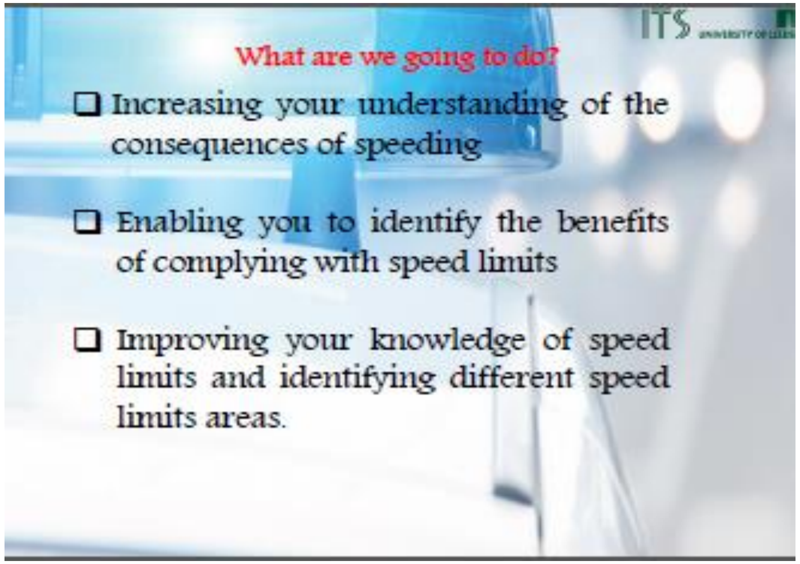
SN	ITEMS	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	The speed warning application system will be effective in reducing my speed	1	2	3	4	5
2	I will drive more safely with the speed warning application system	1	2	3	4	5
3	Using the speed warning application system will improve my driving performance	1	2	3	4	5
4	I will find the speed warning application system useful when I drive	1	2	3	4	5
5	Using the speed warning application system will make it easier to drive	1	2	3	4	5
6	Learning to operate the speed warning application system will be easy for me.	1	2	3	4	5
7	I will find the speed warning application system easy to use	1	2	3	4	5
8	My employer will support my use of the speed warning application system	1	2	3	4	5
9	People who are important to me will support that I should use speed warning application system	1	2	3	4	5
10	I have the knowledge necessary to use speed warning application system	1	2	3	4	5
11	Someone is available for assistance with system difficulties	1	2	3	4	5
12	I intend to use the speed warning application system	1	2	3	4	5
13	I plan to use the speed warning application system	1	2	3	4	5

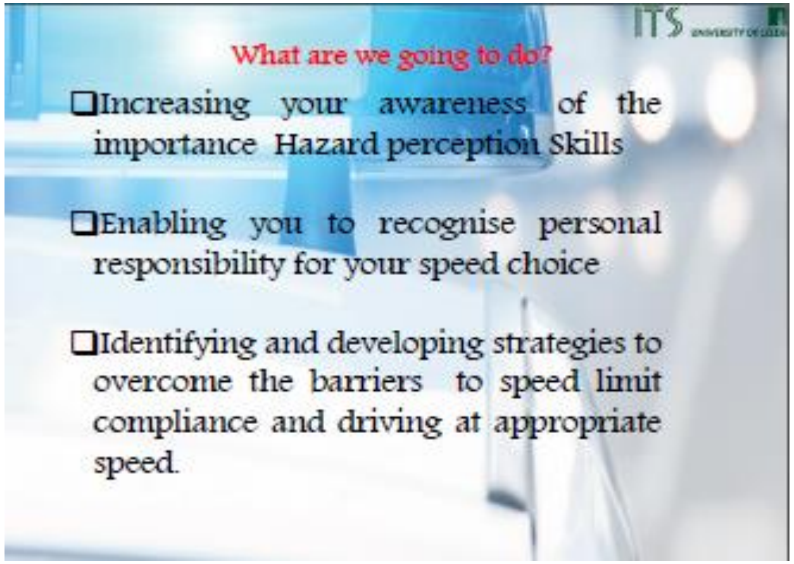
A.4 Speed awareness course materials

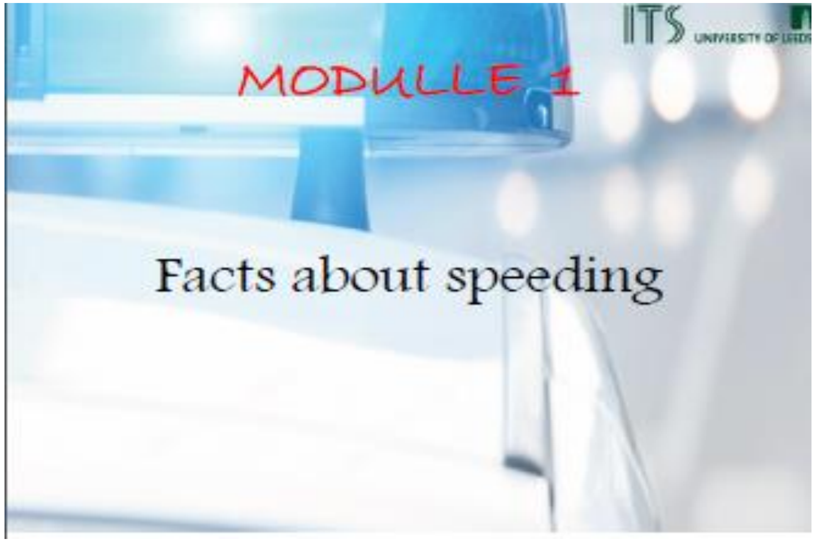



Ice breakers
Still know your highway codes ?


Aim
To increase your motivation to compliance with speed limits and driving at appropriate speed.


What are we going to do?
❑ Increasing your understanding of the consequences of speeding
❑ Enabling you to identify the benefits of complying with speed limits
❑ Improving your knowledge of speed limits and identifying different speed limits areas.

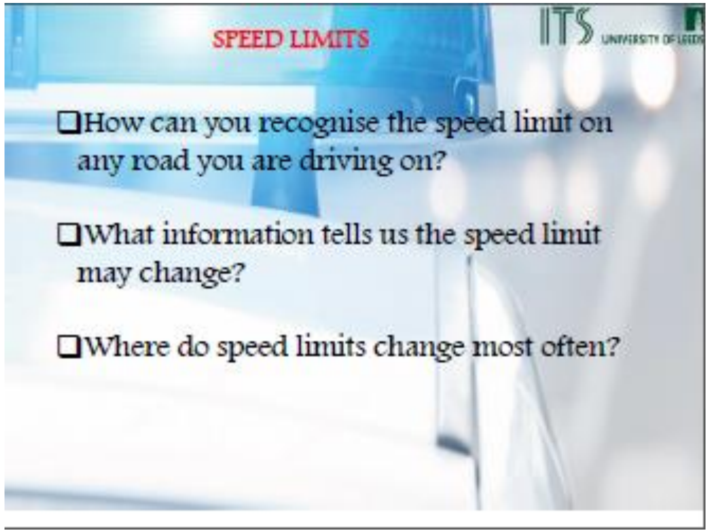

What are we going to do?
❑Increasing your awareness of the importance Hazard perception Skills
❑Enabling you to recognise personal responsibility for your speed choice
❑Identifying and developing strategies to overcome the barriers to speed limit compliance and driving at appropriate speed.


ITS UNIVERSITY OF LEEDS
MODULLE 1
Facts about speeding

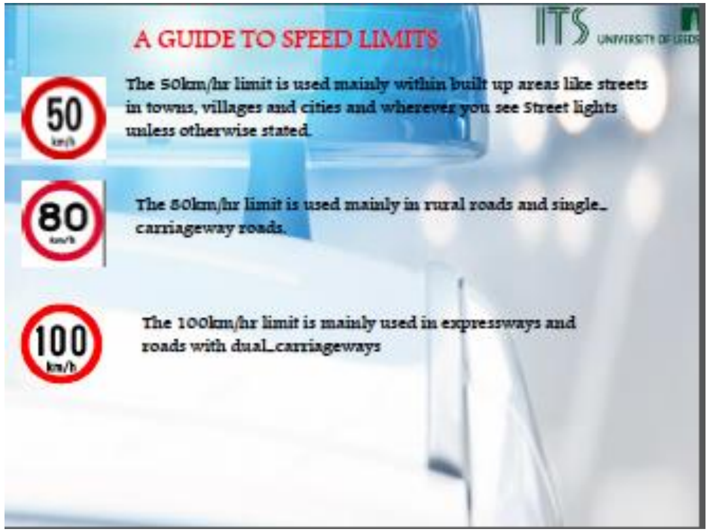

Did you know that
ITS UNIVERSITY OF LEEDS
✓ Every 6 seconds someone is killed or maimed on the world's roads
✓ 4 persons die every hour from road traffic crashes in Nigeria.
✓ 95% of crashes are caused by driver/rider error.
✓ Speeding in the biggest cause of crashes on Nigerian Roads contributing over 50% of the crashes
Speeding is the act of exceeding the posted speed limit or driving too fast for existing conditions
Top 5 Major Causes Of Death In Nigeria
7% Malnutrition
Natural Death


Did you know that
ITS UNIVERSITY OF LEEDS
Impact speed in dry conditions
REACTION
BRAKING
How fast you are travelling when you hit something has everything to do with if you live or die
✓ The risk of involvement in a casualty doubles with each 5km/hr increase in free travelling speed above 60km/hr and
✓ 5km/hr reduction in speed can lead to at least 15% decrease in crashes

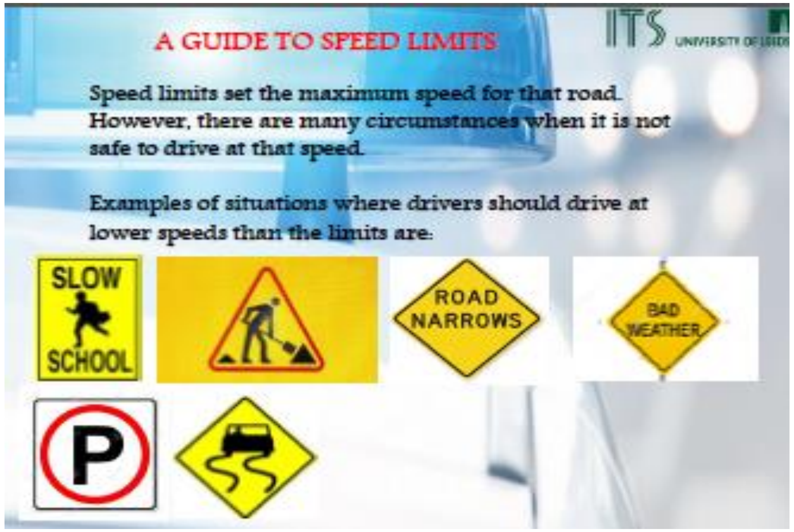

Did you know that
ITS UNIVERSITY OF LEEDS
❑ Hit by a car at 32 km/h, 1 out of 40 pedestrians will be killed – 97% will survive
❑ Hit by a car at 50 km/h, 2 out of 10 pedestrians will be killed – 80% will survive
❑ Hit by a car at 55 km/h, 5 out of 10 pedestrians will be killed – 50% will survive
❑ Hit by a car at 65 km/h, 9 out of 10 pedestrians will be killed – 10% will survive



NIGERIA SPEED LIMITS FOR VEHICLES AND ROAD TYPES IN km/hr			
TYPE OF VEHICLE	Build-up	Highway	Expressway
Motorcycles	50	50	-
Private Cars	50	80	100
Taxis & Buses	50	80	90
Tankers & Trailers	45	50	60
Tow vehicle (While Towing)	45	45	45



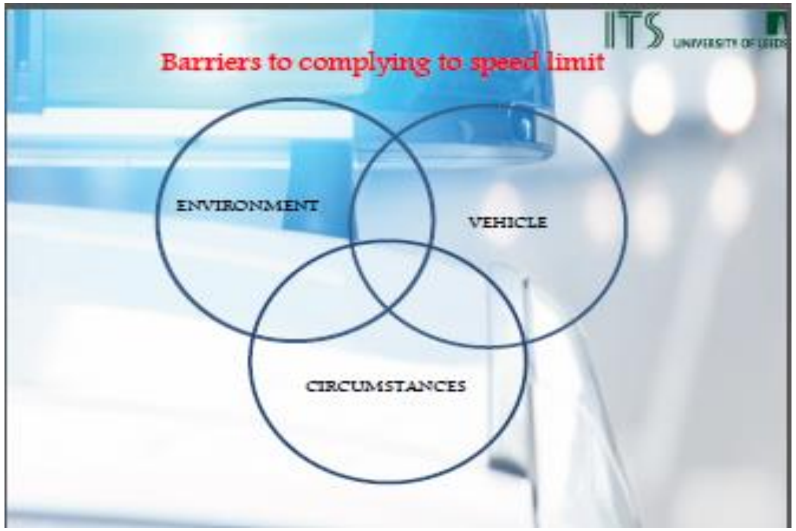

A GUIDE TO SPEED LIMITS
ITS UNIVERSITY OF LEEDS

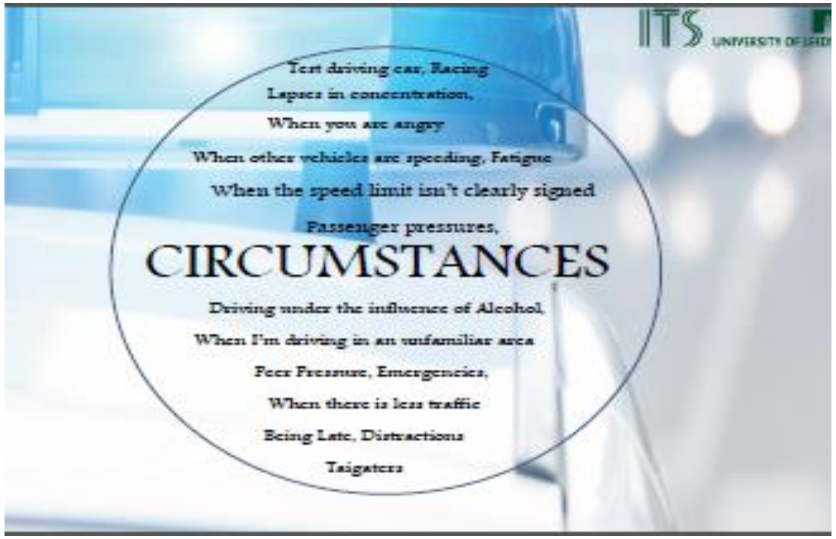

A GUIDE TO SPEED LIMITS
ITS UNIVERSITY OF LEEDS
Speed limits set the maximum speed for that road. However, there are many circumstances when it is not safe to drive at that speed.
Examples of situations where drivers should drive at lower speeds than the limits are:
SLOW SCHOOL
ROAD NARROWS
BAD WEATHER
P


MODULLE 3
ITS UNIVERSITY OF LEEDS
Causes and consequences of speeding


EXCUSES
ITS UNIVERSITY OF LEEDS
HE KEPT TELLING ME TO DRIVE FASTER!

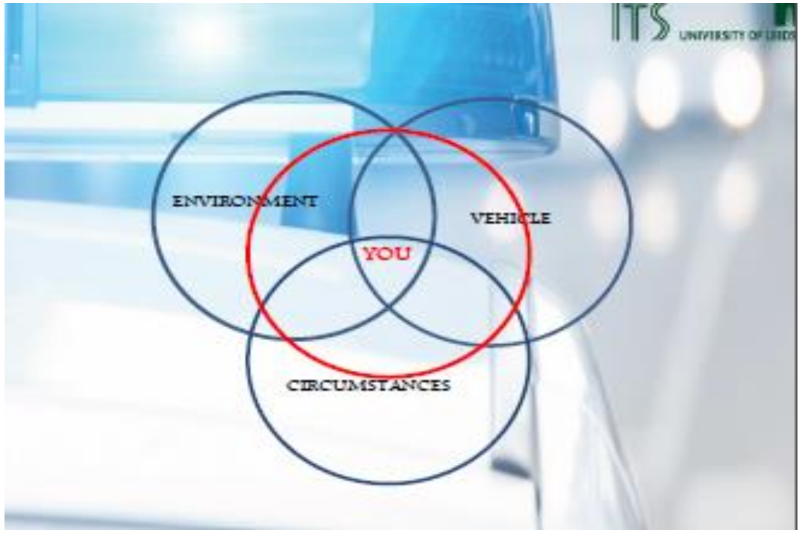

ITS UNIVERSITY OF LEEDS
What causes you to
speed
?


ITS UNIVERSITY OF LEEDS
Barriers to complying to speed limit
ENVIRONMENT
VEHICLE
CIRCUMSTANCES

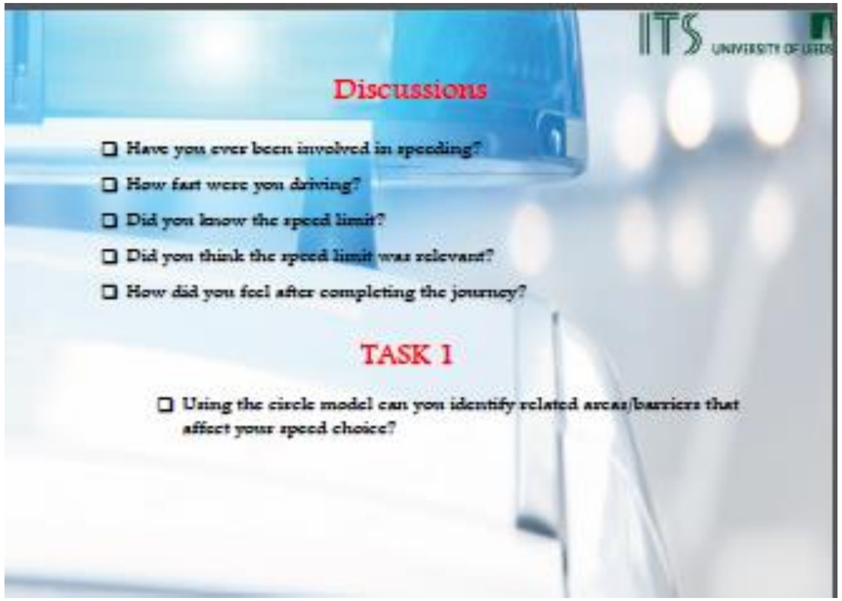

ITS UNIVERSITY OF LEEDS
Test driving car, Racing
Lapses in concentration,
When you are angry
When other vehicles are speeding, Fatigue
When the speed limit isn't clearly signed
Passenger pressures,
CIRCUMSTANCES
Driving under the influence of Alcohol,
When I'm driving in an unfamiliar area
Peer Pressure, Emergencies,
When there is less traffic
Being Late, Distractions
Taigaters


ITS UNIVERSITY OF LEEDS
Driving late at Night
Driving Early in the Morning
When the road is quiet
Distractions
ENVIRONMENT
Unaware of the dangers and Consequences
Sun blocking the speedometer


ITS UNIVERSITY OF LEEDS
Vehicle Performance,
Overestimating your vehicle control
VEHICLE
Misjudging overtaking manoeuvres
When my speedometer is unreliable


ITS UNIVERSITY OF LEEDS
ENVIRONMENT
VEHICLE
YOU
CIRCUMSTANCES


ITS UNIVERSITY OF LEEDS
Thrill Seeking
Test Driving car.
When you are angry
Going with the flow
Wanting to be in front
Lack of self discipline
When the roads are quiet
Listening to music
Failing to observe speed limits
Lapses in concentration
Lack of knowledge on speed limits
Disregard for personal Safety
Feeling of overconfidence in your driving
Misjudge overtake manoeuvre
YOU
Poor speed calibration/perception
Unaware of dangers and consequences
Emergencies/Noble causes
Overestimating your vehicle control
Passenger pressure
Peer Pressure
Being Late
Faulty Speedometers
Tailgaters
Fatigue
Driving under the influence of alcohol

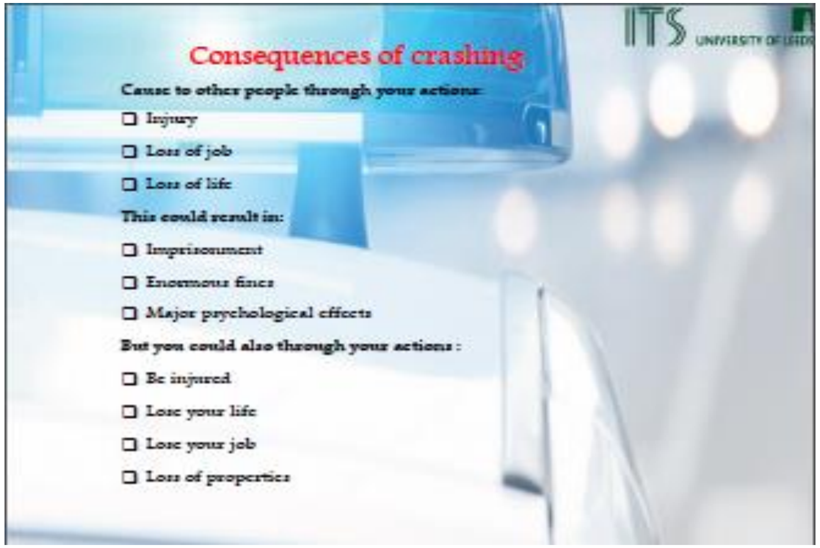

ITS UNIVERSITY OF LEEDS
Discussions
❑ Have you ever been involved in speeding?
❑ How fast were you driving?
❑ Did you know the speed limit?
❑ Did you think the speed limit was relevant?
❑ How did you feel after completing the journey?
TASK 1
❑ Using the circle model can you identify related areas/barriers that affect your speed choice?


ITS UNIVERSITY OF LEEDS
Consequences


Positive outcome of Speeding
ITS UNIVERSITY OF LEEDS
✓Getting there faster
✓Feeling of excitement/thrill
✓Impressing passengers
✓Feeling superior to other drivers
✓Using the car to its full potential


Negative outcome of Speeding
ITS UNIVERSITY OF LEEDS
❑More risk of having a crash
❑More risk of injuring others in a crash
❑More risk of you getting injured in a crash
❑More risk of damage to vehicles in a crash
❑Disapproval from passengers
❑Disapproval from the community
❑More difficult to detect hazards
❑It feels less safe


Consequences of crashing
ITS UNIVERSITY OF LEEDS
❑Psychological effects
❑ Inconveniences
❑Knock on effects with family and friends
❑Loss of job
❑Imprisonment
❑Injury
❑Fines
❑Loss of life
❑Social effects
❑Environmental effect


ITS UNIVERSITY OF LEEDS
Consequences of crashing
Cause to other people through your actions:
❑ Injury
❑ Loss of job
❑ Loss of life
This could result in:
❑ Imprisonment
❑ Enormous fines
❑ Major psychological effects
But you could also through your actions :
❑ Be injured
❑ Lose your life
❑ Lose your job
❑ Loss of properties


ITS UNIVERSITY OF LEEDS
BREAK TIME

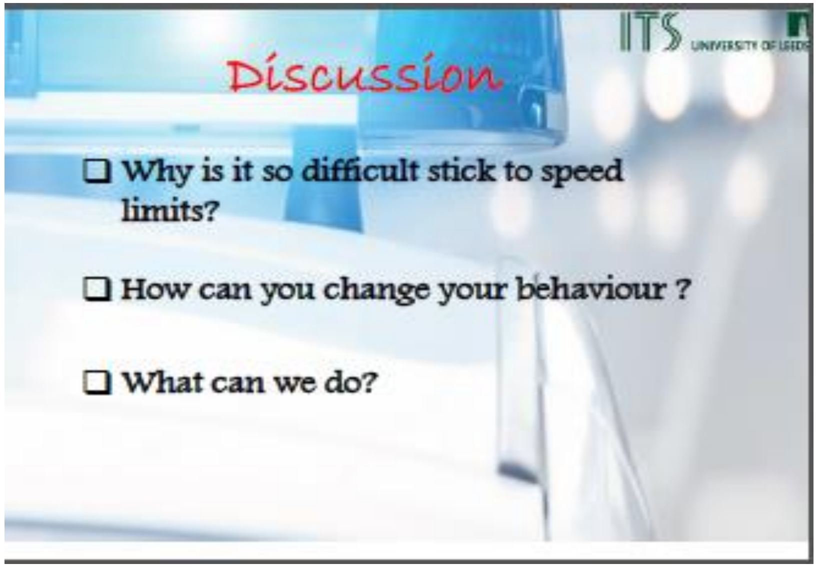

ITS UNIVERSITY OF LEEDS
MODULLE 4
What does the society think about speeding?


ITS UNIVERSITY OF LEEDS
Shell


MODULLE 5
Hazard Perception

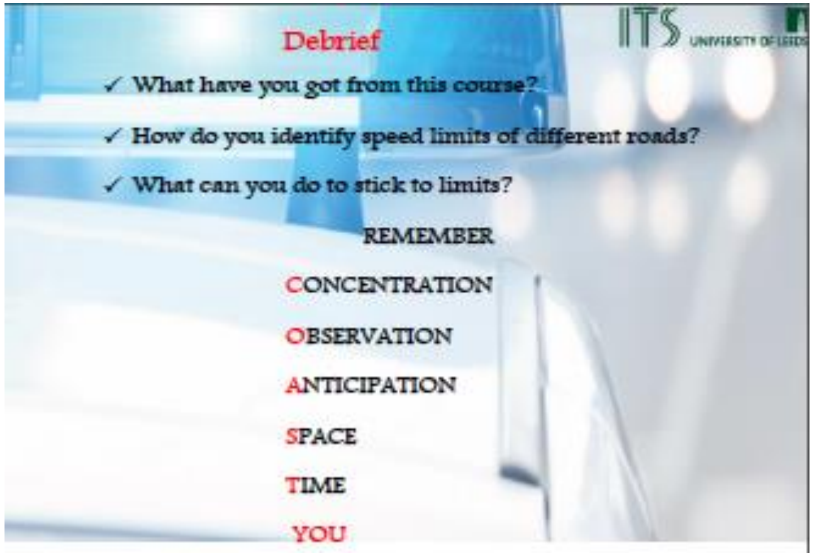

We often look but seldom see

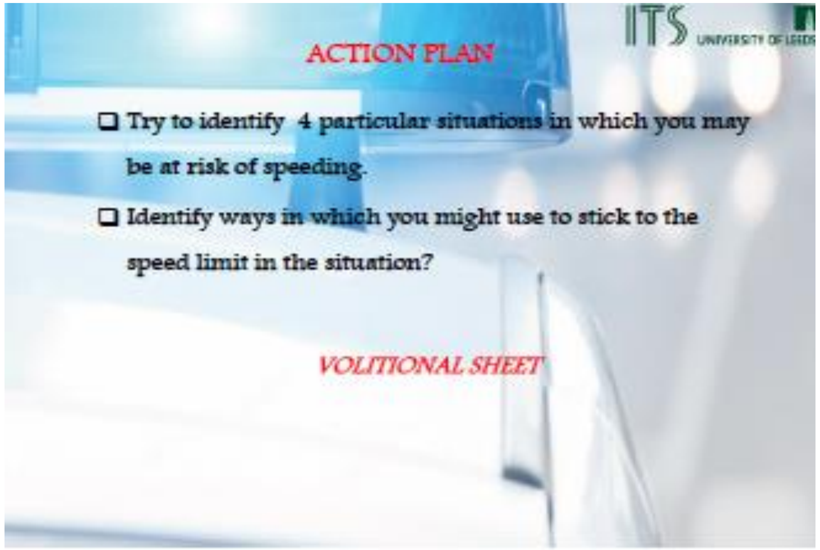

MODULLE 5
Coping Strategy

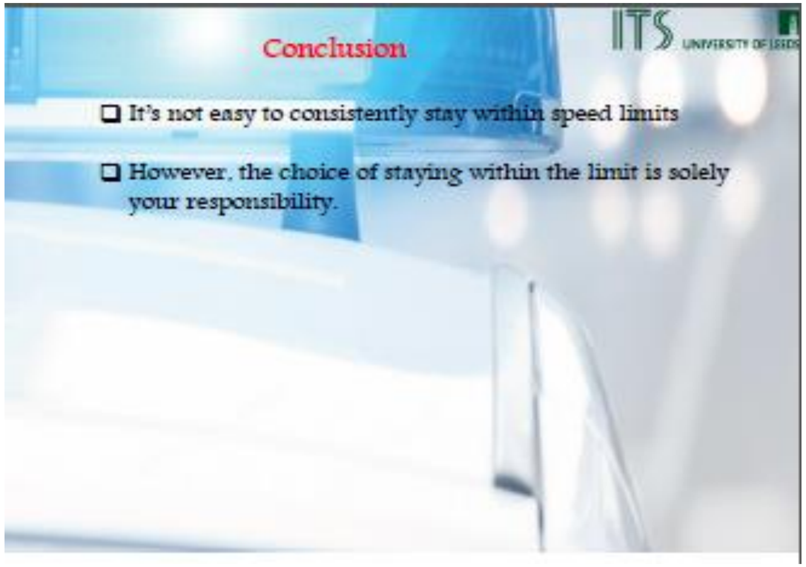

Discussion
❑ Why is it so difficult stick to speed limits?
❑ How can you change your behaviour ?
❑ What can we do?


Coping Strategy
ITS UNIVERSITY OF LEEDS
CONCENTRATION
OBSERVATION
ANTICIPATION
SPACE giving
TIME to time
YOU with self discipline


What you can do?
ITS UNIVERSITY OF LEEDS
CONCENTRATION
OBSERVATION
ANTICIPATION
SPACE
TIME
YOU


Debrief
ITS UNIVERSITY OF LEEDS
✓ What have you got from this course?
✓ How do you identify speed limits of different roads?
✓ What can you do to stick to limits?
REMEMBER
CONCENTRATION
OBSERVATION
ANTICIPATION
SPACE
TIME
YOU


ACTION PLAN
ITS UNIVERSITY OF LEEDS
❑ Try to identify 4 particular situations in which you may be at risk of speeding.
❑ Identify ways in which you might use to stick to the speed limit in the situation?
VOLITIONAL SHEET


ITS UNIVERSITY OF LEEDS
Conclusion
❑ It's not easy to consistently stay within speed limits
❑ However, the choice of staying within the limit is solely your responsibility.

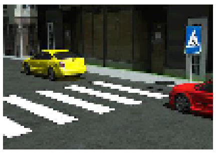

ITS UNIVERSITY OF LEEDS
THANK YOU

A.5 Ice breaker

Highway code quiz

ITS UNIVERSITY OF LEEDS

1. What is the maximum speed limit on a Nigerian road?
2. What is the maximum speed limit for Buses on an expressway in Nigeria?
3. When do you have the right of way on a zebra crossing?



4. **What does this sign mean?**

5. **What does this sign mean?**

6. **On a long motorway journey boredom can cause you to feel sleepy. You should?**
7. **What is the maximum number of hours a driver should drive in a day?**
8. **It is an offence to drive with one hand** TRUE OR FALSE?
9. **It is an offence to reverse on an expressway** TRUE OR FALSE?
10. **What is the maximum speed limit in build-up areas?**

Answers

1. 100km/hr.
2. 90km/h
3. Until you have stepped on it.
4. No overtaking
5. Slippery surface
6. - Leave the motorway
   - Find a safe place to stop
   - Ensure a supply of fresh air into your vehicle
7. 10 hours
8. TRUE
9. TRUE
10. 50km/hr

A.6 Volitional Sheet

Volitional Help Sheet ITS UNIVERSITY OF LEEDS

All drivers speed on occasion, even though they may not intend to. People tend to be more successful at complying with speed limits if they identify situations in which they are tempted to speed and strategies to overcome the temptation. We would like you to do this now using the sheet below. From the list on the left, select up to 4 "tempting situations" (choose the ones in which you know you have the most difficulty complying with speed limits). Then use the list of "strategies" on the right to decide what you will do to resist the temptation to speed when you find yourself in each situation. It is important that you make a link between the tempting situations and the strategies that you select. Draw a line to link each tempting situation that you choose (on the left) with a strategy (on the right). You may choose the same strategy or different strategies to deal with the tempting situations that you select.

'Tempting situations'	'Strategies'
If I am tempted to speed when being overtaken by other traffic/another vehicle…	…Then I will tell myself that I have the ability to comply with speed limits if I want to
If I am tempted to speed in order to keep up with surrounding traffic…	…Then I will think about the emotional pain I would suffer if my speeding caused a death or injury to someone
If I am tempted to speed when under pressure from another driver following close behind me…	…Then I will remind myself that speeding increases my fuel consumption, which is bad for the environment and costs me money
If I am tempted to speed when another driver is putting pressure on me to drive faster by flashing their headlights/sounding their horn…	…Then I will remember that there are people in my life who are supportive of me complying with speed limits
If I am tempted to speed after I have been 'stuck' in stationary traffic…	…Then I will make a concerted effort to ignore the urge/pressure to speed
If I am tempted to speed after I have been 'stuck' behind a slow moving vehicle…	…Then, rather than speed, I will try to relax and drive in a more careful/ considerate/responsible manner
If I am tempted to speed when driving on quiet roads with little or no traffic…	…Then I will tell myself that society is becoming less accepting and tolerant of speeding
If I am tempted to speed in order to get through traffic lights that have started to turn against me…	…Then I will think about how disappointed I would be in myself if I drove faster than the speed limit
If I am tempted to speed when I am listening to certain types of music in the car….	…Then I will remember how upsetting it is to see/hear about road traffic crashes caused by speeding motorists, and the distress caused to the victims and their families
If I am tempted to speed when I am on a long journey …	Then I will remember that I have made a commitment to avoid speeding
If I am tempted to speed when I am feeling stressed…	Then I will remind myself that speeding increases my vehicle emissions, which pollute the environment
If I am tempted to speed when passengers are encouraging me to drive faster (overtly or otherwise)….	…Then I will remember that speeding contradicts the view I have of myself as a considerate person
If I am tempted to speed when I feel the urge to show-off or assert myself…	…Then I will remind myself that I am not saving much time by speeding
If I am tempted to speed when I am late or in a hurry to get somewhere (e.g. work/an appointment/Church/to meet friends)…	…Then I will try to avoid putting myself in that situation again in the future
If I am tempted to speed when driving on familiar roads…	…Then I will remember to tell myself that I am a good driver if I do not speed
If I am tempted to speed when I feel like the car 'wants' to go faster….	…Then I will tell myself that although it might be an easy and enjoyable thing to do, speeding is a harmful and dangerous habit
If I am tempted to speed when driving on straight and wide roads	… Then I would remember the damage I might cause to my car or others car if I crash
If I am tempted to speed when driving past a school…	….. Then I might remind myself that I might go to jail for manslaughter if harmed or killed someone from my speeding.
If am tempted to speed when driving down a road with parked cars	…. Then I would tell myself I am a skilful driver if I am able to control my vehicle speed within the speed limit
If I am tempted to speed when I feel that there is little chance of being caught for speeding …	Then I will drive in a lower gear to help me drive slower.

A.7 Ethical Approval

Research and Innovation Service
Level 11, Worsley Building
University of Leeds
Leeds, LS2 9NL
Tel: 0113 343 4873
Email: ResearchEthics@leeds.ac.uk

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Anderson Etika
Institute of Transport Studies
University of Leeds
Leeds, LS2 9JT

ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee
University of Leeds

21 October 2016

Dear Anderson

Title of study: **Developing an effective Speed Limit Compliance Intervention for fleet drivers in non-fleet settings.**
Ethics reference: **AREA 16-011**

I am pleased to inform you that the above research application has been reviewed by the ESSL, Environment and LUBS (AREA) Faculty Research Ethics Committee and following receipt of your response to the Committee's comments, I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	Version	Date
AREA 16-011 Final ethical Review latest _NM.docx	3	21/10/16
AREA 16-011 Participant Information Sheet .docx	2	27/09/16
AREA 16-011 PARTICIPANTS CONSENT FORM.docx	2	27/09/16
AREA 16-011 Fieldwork_Assessment_Form_high_risk_Anderson Etika_signed_NM.docx	1	02/09/16

Please notify the committee if you intend to make any amendments to the information in your ethics application as submitted at date of this approval as all changes must receive ethical approval prior to implementation. The amendment form is available at http://ris.leeds.ac.uk/EthicsAmendment.

Please note: You are expected to keep a record of all your approved documentation, as well as documents such as sample consent forms, and other documents relating to the study. This should be kept in your study file, which should be readily available for audit purposes. You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits.

We welcome feedback on your experience of the ethical review process and suggestions for improvement. Please email any comments to ResearchEthics@leeds.ac.uk.

Yours sincerely

Jennifer Blaikie
Senior Research Ethics Administrator, Research & Innovation Service
On behalf of Dr Kahryn Hughes, Chair, AREA Faculty Research Ethics Committee

CC: Student's supervisor(s)

A.8 Standard multiple regression examining the prediction of TPB constructs

Standard multiple regression examining association between Intention; and Attitude, Subjective Norm, Perceived Behavioural Control										
TIME 1: PRE-INTEREVENTION										
Variables	Work Vehicle (N=68)					Private Vehicle (N=68)				
	B	β	R^2	Adj R^2	F Δ	B	β	R^2	Adj R^2	F Δ
			.121	.080	2.95[b]			.236	.200	6.58[a]
Attitude	.491	.331[a]				1.002	.469[a]			
Subjective Norm	.161	.206				.132	.104			
PBC	-.078	-.104				.048	.036			
Subjective Norm	-.096	-.183				.067	.081			
PBC	.072	.095				.439	.554[b]			
Standard multiple regression examining association between SELF-REPORTED BEHAVIOUR; and Intention, perceived behavioural control.										
TIME 1: PRE-INTEREVENTION										
Variables	**Work Vehicle (N=68)**					**Private Vehicle (N=68)**				
	B	β	R^2	Adj R^2	F Δ	B	β	R^2	Adj R^2	F Δ
			.081	.052	2.85			.440	.442	25.5[a]
Intention	.026	.037				.450	.620[a]			
PBC	.146	.279				-.188	-.19[b]			
TIME 2: POST-INTEREVENTION										

a= Significant at the 0.01 level (P <.01)
b= Significant at the 0.05 level (P <.05) All beta weights are standardized

A.9 Standard multiple regression examining the prediction of UTAUT constructs

Standard multiple regression examining association between INTENTIONS; and Performance expectancy, Effort expectancy, and social influence.										
Variables	**Time 1 (N=20)**					**Time 2 (N=20)**				
	B	β	R^2	Adj R^2	F Δ	B	β	R^2	Adj R^2	F Δ
			.109	-.058	.654			.457	.355	4.484[b]
Performance Expectancy	.470	.316				.800	.579[b]			
Effort Expectancy	.043	.035				-.137	-.099			
Social influence.	.003	.002				.297	.175			

a= Significant at the 0.01 level (P <.01)
b= Significant at the 0.05 level (P <.05)
All beta weights are standardized