

A System's Approach to Understanding Emerging Driver Habits,  
Perceptions and Practices Exhibited by Ageing South African Drivers:  
The Effects of Age, Sex and Race on Driving

BY

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THESIS

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## ABSTRACT

**Objective:** This study aimed to identify the effects of age, sex and race on driving habits, practices, and perceptions within a South African context. Secondly, the study also aimed to identify the roles that age, sex and race played within the human-car road systems, by employing systems ergonomics theory.

**Methods:** 205 Participants volunteered to take part in this study. Males and females aged 55 years and older were sourced within the Gauteng province. Participants completed two questionnaires, the DHQ, DPPQ and a demographic sheet.

**Results:** Analysis of the DHQ revealed that age, sex and race played a significant role in informing driving habits among South African drivers aged 55 years and above. With the sample population driving on average 6 days a week ( $5.58 \pm 1.52$ ), significant interaction effects concerning age reveal that more attention should be directed towards different age cohorts, as habits are likely to change with increasing age. Coupling the effects of age, sex and race to make inferences on driving habits proved to be complex, suggesting that habits require a nuanced exploration of the interaction between demographic information. With the DPPQ giving insight into perceptions, behaviour, and attitudes, it was determined that there were significant differences between driving practices and perceptions concerning age, sex and race. Different age groups perceive their driving practices and adherence to safety and legislative regulations. Similarly, disparities between the sexes were noted as there were significant differences between how male and female participants viewed their practices and practices when it came to driving. From a system's point of view, it can be said that the factors mentioned above could inform and even further be instrumental in determining road safety and legislative cultures. These findings suggest that there is a need for ongoing research into driving practices on South African roads.

**Conclusion:** With respect to driving, differences in demographical variables elicit differences in habits, perceptions and practices of ageing South African Drivers. A nuanced research approach is required to truly understand the diversity of the ageing/older South African driver population.

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## **LIST OF ABBREVIATIONS**

DHQ: Driver Habits Questionnaire

DPPQ: Drivers Perceptions and Practices Questionnaire

HFE: Human Factors and Ergonomics

ANOVA: Analysis of Variance

MANOVA: Multivariate Analysis of Variance

SA: South Africa

Stats SA: Statistics South Africa

TM: TIBCO Statistica

DBH: Driver Behaviour Questionnaire

DBQ: Driver Behaviour Questionnaire

COVID-19: Coronavirus Disease 2019

EEG: Electroencephalography

fNIRS: Functional Near-Infrared Spectroscopy

NZ: New Zealand

WHO: World Health Organization

# CHAPTER 1: INTRODUCTION

## 1.1 Background

Modern-day life necessitates people's ability to commute between various places for multiple reasons throughout each day. Driving is one method people choose to travel between destinations (Africa, 2020; Cervero, 2013; Janelle & Beuthe, 1997). Driving a car is a complex task, wherein the driver is exposed to visual, auditory and tactile stimuli from both the car and the road (Irwin et al., 2015). The driver therein has to process this information and make informed decisions whilst adhering to road regulations and taking into consideration their safety as well as the safety of other road users (Darçın & Alkan, 2015; Irwin et al., 2015).

Motor vehicle accidents are of great concern worldwide (Lagarde, 2007; Redelmeier & Tibshirani, 1997). To gain a better insight into motor vehicle-related accidents, one must investigate the various factors contributing to a possible accident, one of which is driver behaviour. "Safe" driving remains an ongoing topic where road and traffic safety are concerned (Regan et al., 2011). Multiple factors may affect driving performance, including, among other things, attention, situational awareness, and the driver's decision-making (Alosco et al., 2012; Konstantopoulos et al., 2010; Regan et al., 2011).

It needs to be pointed out that the primary goal of driving is reaching a destination. Driving, as already mentioned, is a complex task. Where human performance and well-being are concerned, ageing is discussed in a manner that elucidates the inevitable biological changes that occur within the process of ageing, and how they impact the human's capability to perform tasks effectively, efficiently, and safely (Conlon et al., 2017; Engel-Yeger et al., 2012; Strasser, 2018). The ageing process is common to all humans, irrespective of demography or socio-economic status.

As the demographic of the ageing adult population continues to grow rapidly on a global scale, societal norms also begin to change accordingly (Department of Economic and Social Affairs, 2023; Posada, 1991, 2003; Sander et al., 2015; Statistics South Africa (Stats SA), 2021; Stats SA, 2017). Characterised by its diverse

population, democratic South Africa continues to paint a picture of Apartheid constructed legacies that lead to unique and unequal sociocultural dynamics that persist in modern-day South Africa (Seekings & Nattrass, 2004; Khosa', 1995; Pirtle, 2022; McCarthy, 1990; Pellicer & Ranchhod, 2023). Driving a car as a form of transportation can assert feelings of independence and a better quality of life in the lives of ageing adults, irrespective of age-related changes that may adversely affect their mobility (Covinsky et al., 2003; Department of Economic and Social Affairs, 2023; Posada, 2003; Ralston, 2018). Changes in cognition and physiology can pose challenges for safe and efficient driving (Albert et al., 2018; Brelet et al., 2016; Dickerson et al., 2019a; Donorfio et al., 2008a; Kaye et al., 2018).

While Apartheid may have brought about race-related complexities, sex was historically also used as a discriminatory tool within society (Bergdahl, 2005; Jeremy Seekings & Nattrass, 2004; Pellicer & Ranchhod, 2023). Within a South African setting, gender roles have and continue to shape social norms and practices (Bergdahl, 2005; Seekings & Nattrass, 2004; Møller & Gregersen, 2008). Gender roles dictated who could drive, where, and how, often with the male being seen as more competent (Bergdahl, 2005; Seekings & Nattrass, 2004; Møller & Gregersen, 2008). The implications thereof brought about unique social disparities within South Africa, while race may have been an overarching tool of discrimination, age and sex compounded these (Seekings & Nattrass, 2004). Within racial groups, culture affected social practices; hence, older males could still be considered socially superior to women or anyone younger (Seekings & Nattrass, 2004).

South Africa's unique socio-cultural and socio-demographic makeup opens up research opportunities that are better targeted to South Africans while building upon existing global research findings. Shedding light on the role complex back-and-forth between age, race and sex, and how they affect driving habits, practices, and perceptions can provide better insight into the advancement of the greater South African road network system, as well as its associated laws and policies.

## **1.2 Aims**

The primary aim of this study was to identify the habits, perceptions and practices of ageing South African drivers based on race, age and sex. The secondary aim was to investigate the role played by the ageing South African driver within the human-car-road system using the system's ergonomics principles. Previous research (Ball et al., 1993a; Coxon et al., 2017a; Stalvey & Owsley, 2000) investigated how the ageing adult population may or may not have made changes to their driving patterns over the years. Be it as advised by loved ones or as a conscious, individual decision (Ball et al., 1993a; Coxon et al., 2017a; Stalvey & Owsley, 2000). These studies looked into self-perceptions of elderly drivers and how or if they modified their driving practices. These studies, particularly by Stalvey & Owsley (2000), informed this body of research. Their interest stems from the fact that they conducted their studies in the Western world. Given the diversity within the South African population, it was assumed that demographic representation would differ in different parts of the world. Conducting a similar research project by applying it to a South African context can inform better safety practices within South Africa, as well as enforce regulations and interventions that apply to South Africans. Once more, it is important to note that while three demographical variables have been touched on, age will be underpinning the vast majority of this research as it occurs across all sex and race.

## **1.3 Thesis Layout**

This dissertation has been divided into six distinct chapters, namely Chapters 1 to 6. This thesis layout provides insight into each chapter and what it pertains to. Chapter 1 comprises an introductory chapter. This chapter informs the background and the aims leading to the conception of this project. This section also includes a structural overview of the chapters to follow.

Chapter 2 is dedicated to the Literature review. In this review, the reader will be introduced to the concepts of driving and its related challenges as per the variables identified in Chapter 1. The chapter provides in-depth reviews of South Africa's unique socio-demographic factors influencing the task of driving and understanding a system's ergonomics framework concerning the complex human-car-road system.

Furthermore, this chapter also served to identify gaps in the literature that would be important for this particular research.

Chapter 3 outlines the methodology developed to answer the research question. The research design gives an overview of the data collection tools, together with a justification of the cross-sectional design used. The methodology goes further to detail participant sampling as well as recruitment. Included in the data tools identified, it was noted that the questionnaires used were adapted to better suit South African driving scenarios. Furthermore, ethical considerations such as consent are addressed. Lastly, the statistical analyses used are also presented, with the necessary justifications.

Presented in Chapter 4, the results section is a detailed presentation of the findings from the data collection processes. While there are tables and graphs presented, those deemed less important can be located in Appendices C and D. The focus of this section can be divided into the statistical analyses used - descriptive and inferential statistics. Inferential statistics comprised of t-tests, ANOVA and MANOVA. These are presented both visually (key findings) and in written form. It is in this chapter that the effects of age, race and sex are presented, and distinct findings are reported.

Chapter 5 gives a detailed discussion of the results. This includes the interpretation of the key findings. This incorporates a comprehensive interpretation of how age, sex and race influence driving habits. Comparisons with international studies are also presented. Concerning the Human-Car-Road system, the principles of systems ergonomics are made applicable to the key findings. Additionally, the strengths and limitations of the study are presented together with suggested directions for future research.

Conclusions and limitations are subsequently outlined in Chapter 6. All literary resources used are represented in the reference list, while a table of figures is included in the beginning of the document. Appendices referred to throughout the document can be found at the end of the document.

## **CHAPTER 2: LITERATURE REVIEW**

In alignment with human civilisation and development, transportation has been a vital tool for human mobility (Acheampong & Silva, 2015; Africa, 2020; Dempsey, 2003; Janelle & Beuthe, 1997). Transportation is not only imperative but vital within modern-day society. Transportation greatly facilitates the movement of goods and people around their surroundings and the world at large (Banister, 2012; Dempsey, 2003; Janelle & Beuthe, 1997). Over time, modes of transportation have evolved from more simplistic forms to more complex modes, as can be found in modern-day society (Acheampong & Silva, 2015; Banister, 2012; Janelle & Beuthe, 1997). On-road modes of transportation, such as driving, enable efficient movement of goods and people between various places (local and international), economic development via trade and ongoing globalisation advancements (Møller & Gregersen, 2008; Ramos et al., 2020).

### **2.1 Contextualising Driving Within South Africa**

The act of on-road driving is dynamic in that while the driver may be able to control the vehicle, they are not able to control factors such as road conditions, changing weather patterns, as well as the behaviour of other road users (Lu et al., 2017; Scialfa et al., 2012). Driving is an open skill (Cantin et al., 2009a; Irwin et al., 2015), whose success is determined by the drivers' ability to adapt to the changing environment (Cantin et al., 2009; Horberry et al., 2006; Lu et al., 2017). Thus, the driver's decision-making becomes an area of interest. The term "open skills" refers to motor or cognitive skills performed in environments of high variability and unpredictability, wherein the person performing those skills must continuously adapt their movements and or decisions in response to the changing environment (Cantin et al., 2009b; Isler et al., 2011; Poulton, 1957).

Safe driving requires a wide range of skills and abilities (Horberry et al., 2006). This is because driving does not always occur under "ideal" conditions, wherein the road and weather conditions are predictable and controllable. This particular point will be dissected in greater detail in section 2.2, where behaviour is discussed.

It is vital to highlight the impact of South Africa's history on not just driving, but also understanding the additional unique challenges that may or may not exist in other countries (Africa et al., 2021; Cervero, 2013; Seekings & Nattrass, 2004). The policies of Apartheid South Africa enabled glaring disparities between South Africans, based on racial bias and preferences, marginalising and rendering those classified as anything other than white, adversely affected. ( Africa et al., 2021; Cervero, 2013; Czegledy, 2004; Seekings & Nattrass, 2004). While Apartheid may be over, the legacy of its policies continues to affect modern-day South Africa.

One may argue that mentioning this would seem rather trivial; however, it allows this research project to parallel the differences between driving-related challenges in a developing South Africa and more developed Western countries. The differences and disparities driven by apartheid policies trickled over into South African transportation, creating unique social, economic, and political development dynamics (Seekings & Nattrass, 2004).

Apartheid facilitated urban planning, ensured that the mobility of non-white South Africans was limited, particularly for the black South African (Czegledy, 2004; Seekings & Nattrass, 2004; Khosa', 1995; McCarthy, 1990). The legislated Group Areas Act of 1950, much like other apartheid acts, purposefully divided urban areas into racially exclusive zones, subsequently pushing Black, Coloured and Indian people outside city peripheries (Seekings & Nattrass, 2004; Khosa', 1995; McCarthy, 1990). This is particularly relevant to this literature review as it informs sociodemographic factors that shaped South Africa's road and transport policies.

The mandated classification of people according to race ensured that factors such as government support, legal rights and most importantly to this review, geographic mobility (Pirtle, 2022; Pellicer & Ranchhod, 2023), were administered based on racial hierarchy. The hierarchy was such that white people received the most rights and privileges, followed by Indian people, Coloured people, and lastly Black people. The stark emphasis on race thus makes race a relevant factor in understanding the South African driver and the broader transportation system. On a social level, the history of South Africa was not only based on apartheid but on worldwide beliefs and constraints around feminism and ageism. While these are important to note, they will not be

discussed in great detail as they fall beyond the scope of this research project. However, they are discussed succinctly due to how they intersect with race.

What is important to note is that race, sex, and age are compounding factors that inform the research question. The term age is used to describe the length of existence (Cox et al., 2014; Tallis, 1993). On the other hand, sex is used to (Arnegard et al., 2020; Bergdahl, 2005; Jassat et al., 2022) differentiate between biological males and females. The interactions of these three sociodemographic factors will be discussed in greater detail following the section on interpreting behaviour.

Having outlined the premise of this research project, it can thus be said that while studying any driving or transport-related topic within a South African context, it is important to look into how sociodemographic factors such as race, sex, and age inform driving-related behaviours. This is, of course, discussed from an ergonomics point of view.

## **2.2 Contextualising Behaviour in Ergonomics**

Race, sex and age greatly affect human behaviour (Ajzen, 2011; Seekings & Nattrass, 2004; Møller & Gregersen, 2008; Welch, 2016). As previously mentioned, this is not unique to South Africa, but the wider global community, as discussed in the works of researchers such as Wagner et al. (2011); Bergdahl, (2005) and Shults et al. (2016).

Humans inherently go about everyday life driven by certain behaviours (Ajzen, 2011; Allen et al., 2019; Brenman-Suttner et al., 2020; Miller et al., 2001). Behaviour is a core concept within the field of psychology and impacts how humans interact with the world around them (Hargreaves, 2011; Miller et al., 2001; Xu et al., 2017). As a scientific discipline, ergonomics is heavily influenced by these concepts (Bridger, 2008a; Wilson, 2014).

Within the confines of this research project, it helps contextualise the importance of understanding basic psychology concepts and translating them into how humans ultimately interact with any given task, in this case, driving. Habits, practices, and perceptions are behavioural concepts.

It is important to note that while this literature review explores behavioural concepts and frameworks, this project explicitly delves into these concepts from an ergonomics perspective.

Significant amounts of research within the following research fields: biology, psychology and neuroscience pay close attention to ergonomic-specific functions and elements, and how they may interact. (Anstey et al., 2012; Conlon et al., 2017; Nash et al., 2016). Ergonomics, however, was historically overlooked (Bentley et al., 2021; Greig et al., 2019a; Shorrock & Williams, 2016a; Strasser, 2018). However, the works of Rasmussen (1983) heavily influenced the framework of systems ergonomics. This will be expanded upon in section 2.3 of this chapter.

As a central focus within psychology, the term “behaviour” encapsulates a wide range of actions and responses, as well as the interactions demonstrated by people (Aunger & Curtis, 2008; Skinner, 1984; Uher, 2016). Due to the multidimensional factors and models surrounding behaviour, definitions may vary. However, given that this body of research is ergonomics-focused, explorations into the theoretical models and contextual influencing behaviour are outside the scope of both practice and interest. For this review, the term “behaviour” will describe observable actions demonstrated by individuals, and can be measured and analysed (Aunger & Curtis, 2008; Skinner, 1984).

Based on the definition above, Habits, Practices and Perceptions can be contextualised. Human behaviours, as a focal point in psychology, shape how people interact with their environments daily (Ajzen, 2011; Aunger & Curtis, 2008; Skinner, 1984; Uher, 2016).

A combination of social, emotional, cognitive and external environmental factors influences behaviour (Henriques & Michalski, 2020). Habits occur as a result of repetitive actions, which ultimately become automatic responses (Henriques & Michalski, 2020; Tang & Won, 2018). Perceptions refer to the process by which humans organise and interpret sensory information received, and interpret this information to make sense of their external environment (Lekan, 2007; Uher, 2016; Welch, 2016). Practices, on the other hand, refer to repeated behaviours that are reinforced by society and culture (Lekan, 2007; Molnar et al., 2014; Welch, 2016).

For clarity and to contextualise the purpose of this research, the three behavioural factors will be illustrated through a driving-related example. A person driving from point A to point B will demonstrate each of these concepts.

*Habits:* The driver may travel at a certain speed

or neglect safety precautions, such as failing to indicate when turning. These habits may have developed from frequently driving along the same route and observing the behaviours of other drivers, which reinforce norms. For instance, the driver may consistently drive fast and fail to indicate, because they've always driven that way on this route, and no negative consequences have occurred.

*Perceptions:* The driver may observe others behaving similarly on the road, reinforcing the belief that such actions are acceptable, even if they are contravening traffic laws and regulations

*Practices:* The driver continues to drive in their habitual manner and may even encourage others to do the same when acting as a passenger, giving directions.

### 2.2.1 Habits

After reading the definition of the term "habit" and the above-mentioned example, additional deductions and expansions can be made. First, habits ultimately become automatic, as confirmed in the articles presented in the table below.

Table 1: References for Habit Automation

| <b>Title</b>  | <b>Reference</b>             |
|---|------------------------------|
| Controlled and Automatic Human Information Processing: I. Detection, Search and Attention                     | (Schneider & Shiffrin, 1977) |
| How Design Influences Habits  | (Tang & Won, 2018)           |
| Skills, rules, and knowledge; signals, signs, and symbols, and other distinctions in human performance models | (Rasmussen, 1983)            |
| Actions, Habits, and Practices  | (Lekan, 2007)                |

The onset of habits is prompted by external environmental cues, and the repeated “reaction” to said cues is learned and adopted. In his work titled “The Power of Habit”, Duhigg (2012) attributes the automation of this behaviour to a process called habit formation. The repetition of behaviours, within recurring contexts, becomes reinforced by favourable outcomes, i.e. people gradually learn to associate actions, context and resultant outcomes (Lekan, 2007; Schneider & Shiffrin, 1977; Tang & Won, 2018).

The process of habit formation results in the creation of additional neural pathways in the brain when external stimuli are interpreted, resulting in the newly learnt behaviour becoming automatic over time (Lekan, 2007; Schneider & Shiffrin, 1977; Skinner, 1984, 2005; Tang & Won, 2018). This occurs irrespective of whether or not the habit is good or bad. The frequency of action and the cognitive processes that develop through the frequency of association are used to determine habits (Lekan, 2007; Ramos et al., 2020; Tang & Won, 2018). It can thus be said that habits are repetitive and automatic. Given that neural pathways are created for habits to form, advancement in age could thus mean that habits are heavily ingrained and are probably hard to change. It is henceforth that we can assume that with advancing age, older drivers will be less inclined to change their habits or become accustomed to new ones.

### 2.2.2 Perceptions

When it comes to perception, interpretation is the focal point. Perception is highly characterised by context (Albright, 2015; Dror & Schreiner, 1998). The colloquial and most often referred to definition of “perception” is the act of understanding, realising, seeing, noticing, or becoming aware of something. Perception is a process whereby the human intake sensory information from their external environment, by means of any of the five senses- sight, touch, hearing, taste, smell and construct meaningful interpretations of the external environment (Albright, 2015; Dror & Schreiner, 1998; Tuokko et al., 2007). Perception is an active process influenced by factors such as emotions, social influences and personal biases (Albright, 2015; Dror & Schreiner, 1998; Scialfa et al., 2012b; Wood et al., 2016). Therefore, two people can perceive the same stimulus and interpret it differently.

### 2.2.3 Practices

Practices, as previously mentioned, are repeated actions or behaviours performed regularly, often within a social or cultural context. They are usually learned behaviours that are shaped by social norms, traditions, and personal experiences. Practices can range from daily routines to professional activities and rituals. They reflect an individual's or group's way of doing things and can vary across different cultures or settings (Ang et al., 2020; Lekan, 2007; Molnar et al., 2014).

## 2.3 Systems Ergonomics and Driving

Driving is an open skill (Cantin et al., 2009; Irwin et al., 2015). Success in driving is determined by the driver's ability to adapt to the changing environment (Cantin et al., 2009; Horberry et al., 2006; Lu et al., 2017). Thus, the driver's decision-making becomes an area of interest. Safe driving requires a wide range of skills and abilities (Horberry et al., 2006). This is because driving does not always occur under "ideal" conditions wherein the road and weather conditions are predictable and controllable.

On-road driving is dynamic in that while the driver may be able to control the vehicle, they cannot control factors such as road conditions, changing weather patterns, or the behaviour of other road users. (Lu et al., 2017; Scialfa et al., 2012). Trying to gain insight into cognitive workload and risk perception while driving requires firstly that we acknowledge that one cannot simply study the driver in isolation, but take on the approach of trying to understand the interactions between the human (i.e. the driver), the vehicle and the road (Klauer et al., 2006). Unless stated otherwise, the word "human" will refer to the person controlling or driving the vehicle for the rest of this project. Thus, it is important to acknowledge that three elements exist: the human, vehicle, and road (K. Edwards & Jensen, 2014; Klauer et al., 2006; Larsson et al., 2010; Wilson, 2014). These three elements will be expanded on later in the review.

Human Factors and Ergonomics (HFE), is a people-centred, design and systems discipline (Bentley et al., 2021; Greig et al., 2019; Strasser, 2018; Thatcher & Yeow, 2016). In essence, the principle behind HFE is the contribution to efficient human performance and well-being, using the application of systems design (Eby & Kantowitz, 2006; Grote, 2014; Hollnagel, 2014; Schutte, 2005; Wilson, 2014; Wilson & Carayon, 2014). The necessity to discern people's relationships and interactions allows ergonomists and other collaborative colleagues to ultimately improve and introspect on how interactions could be improved.

Wilson (2014) states, “A system is a set of inter-related or coupled activities or entities, with a joint purpose, links between the entities which may be of state, form, function and causation, and which changes and modifies its state and the interactions within it given circumstances and events, and which is conceptualised as existing within a boundary; it has inputs and outputs which may connect in many-to-many mappings, the system as a whole is usually greater (more useful, powerful, functional etc) than the sum of the individual parts.” (Bridger, 2008b; Wilson, 2014). .

This means that a system and its interrelated components should have a common purpose (Hollnagel, 2014; Wilson, 2014). The relationship between the different elements of a system affects each other, subsequently modifying all other subsystems within the system at large. This takes place within a context or boundary (Hollnagel, 2014; Schutte, 2005; Wilson, 2014), as one has to consider not just the basics of each element of the system, but its inter- and intra-related interactions, as observed from various viewpoints of the system. Having said this, we can make an inference that systems have varying levels of “complexity”, which coincides with the fact that driving is viewed as a complex task.

The oversimplification (reductionism) of an element of a system, however, is based on the sole analysis of said element (Grote, 2014; Wilson, 2014), as knowledge specific to that discipline can lead to great oversight. Skyttner (2005) argues that if reductionism is used, the mutualistic properties of a system may be lost. This corresponds to literature, old and new, which has changed over the years to broaden the understanding of systems theories. The newfound consensus amongst researchers is that, as an organised unit, the interdependent components of the system can indeed be defined by each other (Grote, 2014; Hollnagel, 2014; Wilson, 2014).

The need for transportation is based on a person’s individual needs, responsibilities or obligations. People, therefore, commute for various reasons, and that often dictates their chosen mode of on-road transportation.

The world has seen an increase in the ageing population (Department of Economic and Social Affairs, 2023) and South Africa has also provided statistics to confirm this (Phakedi, 2023; Statistics South Africa (Stats SA), 2021). With the increase in the number of adults, it is expected that more people will need to commute, particularly

for work reasons, as global trends have identified positive links between ageing adult populations and prolonged labour practices. Despite changes in our socio-political system, some of apartheid's urban planning still forces people to travel significant distances to and from work. As mentioned, other factors may require people to commute. Driving research is a focal point globally, but not so much where South African drivers are involved, particularly those over the age of 50 years. Calls for researchers to identify or become aware of the unique challenges (i.e. due to the ageing process) that ageing or older drivers experience as opposed to their younger counterparts (Conlon et al., 2017b; Gwyther & Holland, 2012; Song et al., 2015; Sullivan et al., 2011).

Driving places a high demand on cognitive, perceptual and motor processes (Ross et al., 2014). The development of working memory capacity is largely dependent upon the maturation of the prefrontal cortex and parietal lobes, which can last up until the age of 25 (Baddeley & Hitch, 2013; Ross et al., 2014). In addition, many aspects of driving, such as vehicle control and driving routines, only become automated over time and with increasing driving experience (Furley & Memmert, 2010; Ross et al., 2014; Wood et al., 2016) .

Non-automated tasks require more working memory resources than automated tasks; as a result, novice drivers utilise greater working memory resources during driving tasks (Cordazzo et al., 2014; Paxion et al., 2014, 2015; Stalvey et al., 2000). What this translates to is that for older, more experienced drivers, the driving task may become automated, and their anticipation of possible risks may be better than that of less experienced drivers, allowing them to better mitigate risky situations that may arise in driving (Rhodes & Pivik, 2011; Siren & Meng, 2013). This occurs despite age-related changes (e.g. decreased vision and decline in reaction time) that are meant to adversely affect the precision and accuracy with which one ought to drive.

The definition of complexity in ergonomics is vast, however, having come across several bodies of literature (Righi & Saurin, 2015; Ryan et al., 2021; Saurin & Gonzalez, 2013; Walker et al., 2010), it refers to the unpredictability that may occur within a system due to the dynamic interactions between several players within that system. Following the definition of a system as defined by Wilson (2014), the criteria used to ascertain the nature of a system (Baxter & Sommerville, 2011; Righi & Saurin,

2015; Skyttner, 2005; Wilson, 2014) are a set of related activities or entities occurring within a boundary, with a joint purpose. The primary purpose of driving, as previously mentioned, is to move from one point to another.

Within the human-car-road system, there is a human (social being) operating a car (non-human), within a particular context (Gauteng roads). Based on these characteristics, the human-car-road system will henceforth be viewed as a socio-technical system (Mittal & Rainey, 2015; Oosthuizen & Pretorius, 2016; Oosthuizen & Wout, 2019; Saurin & Gonzalez, 2013). The figure below provides clarity on the general characterisation of socio-technical systems

| Attributes   | Key characteristics of the attributes  |
|--|--|
| A large number of dynamically interacting elements | <ul style="list-style-type: none"> <li>- The system changes over time</li> <li>- The interactions are non-linear</li> <li>- The interactions take place among tightly-coupled elements</li> </ul>  |
| Wide diversity of elements                         | <ul style="list-style-type: none"> <li>- The elements are differentiated according to a number of categories, such as hierarchical levels and specializations</li> <li>- The nature of the relations among the elements exhibits variety, in terms of aspects such as degree of co-operation and degree of shared objectives</li> </ul>  |
| Unexpected variability                             | <ul style="list-style-type: none"> <li>- Uncertainty, which is a result of the richness of the interactions between the elements as well as from the fact that elements receive information from indirect or inferential information sources</li> <li>- Complex systems are open, which means that they interact with their environment</li> <li>- Emergence is a well-known manifestation of unexpected variability. An emergent phenomenon arises from interactions among the elements, independently on any central control or design</li> </ul>  |
| Resilience   | <ul style="list-style-type: none"> <li>- It is the systems' ability to adjust their functioning prior to, during, or following changes and disturbances, so that the system can sustain required operations under both expected and unexpected conditions.</li> <li>- Performance adjustment means filling in the gaps of procedures, whatever their extent and reason, such as under specification for an expected situation or inapplicability for an unexpected situation</li> <li>- Performance adjustment is guided by feedback, both from recent events and from the earlier organization's history</li> <li>- Self-organization, which enables a complex system to develop or change internal structure spontaneously and adaptively in order to cope with their environment</li> </ul> |

Figure 1: The Defining Attributes of a Socio-Technical System (Saurin & Gonzalez, 2013)

## 2.4 The Complex Socio-Technical System

A complex sociotechnical system is an interdependent or mutually dependent network comprised of human, social, and technological components that interact dynamically within an environment to achieve specific objectives or tasks (Carayon, 2006; Grote, 2014; Hettinger et al., 2015; Righi & Saurin, 2015). Each subsystem is characterised by its complexity, adaptability, and emergent properties, meaning that its behaviour is not simply the sum of its parts but results from intricate interactions among its

components (Mittal & Rainey, 2015; Szabo et al., 2019; Szabo & Birdsey, 2017; Wilson, 2014; Wilson & Carayon, 2014).

#### 2.4.1 The Social Subsystem

A nuanced approach needs to be taken when referring to the social subsystem of a complex socio-technical system. This comes as the social subsystem refers to all human-centred components that act on the system, subsequently influencing the interactions between the other elements as well as how the system functions (Carayon, 2006; Kahlen et al., 2016; Righi & Saurin, 2015; Walker et al., 2010; Wilson, 2014). In the human-car-road system, the social subsystem would comprise the following elements: the driver, other drivers and road users (e.g. pedestrians), law-makers and law enforcement. Human beings are inherently dynamic by nature as their habits and behaviours are affected by a plethora of factors, both intrinsic and external (Carayon, 2006; Righi & Saurin, 2015; G. H. Walker et al., 2010). Examples of these may include culture, socialisation and health (Eby & Kantowitz, 2006; Greig et al., 2019; Guastello, Stephen, 2018; McCarthy, 1990; Pellicer & Ranchhod, 2023; Righi & Saurin, 2015; Shorrocks & Williams, 2016; Welch, 2016). For this particular research project, the human-centred element that will be focused on is the driver of the car. Age, race and sex will be the variables focused on. Contextualisation of each concept is given based on the degree to which it applies to this research. Everything beyond the scope of ergonomics or of this particular research has purposefully been omitted.

**Age:** Almost all living organisms experience the process of ageing (Brenman-Suttner et al., 2020; Ralston, 2018; Sander et al., 2015). The term “ageing” can be broadly interpreted as any change occurring in an organism over a period of time, and is often associated with a progressive deterioration of both function and fertility, in addition to an increased inclination to death (Amarya et al., 2018; Brenman-Suttner et al., 2020; Cox et al., 2014; Sander et al., 2015; Strasser, 2018).

An increase in age is often accompanied by various life challenges (e.g. a decline in health), and these challenges present a negative impact on the independence of older adults, together with their social interactions with others (Amarya et al., 2018; Bieirń, 2005; Bowling, 2011; Collerton et al., 2007; Waddell & Jacobs-Lawson, 2010).

Depending on the limitations, the said challenges could play a role in determining the well-being of the older adult (Bieić, 2005; Collerton et al., 2007; Ralston, 2018; Waddell & Jacobs-Lawson, 2010), and thus ultimately affecting the interaction between the human-car-road system, wherein the human is the ageing/older adult.

Driving places a high demand on cognitive, perceptual and motor processes (Ross et al., 2012; Ross et al., 2014). The development of working memory capacity is largely dependent upon the maturation of the prefrontal cortex and parietal lobes, which can last up until the age of 25 (Borisov et al., 2018; Damiani et al., 2009). In addition to that, many aspects of driving, for example, vehicle control and driving routines, only become automated over time and with increasing driving experience.

The ability to drive is often affected by deficits relating to neurological disorders and age-related changes (Ball et al., 1993; Casutt et al., 2014; Cox et al., 2014; Pavlou et al., 2017; Tallis, 1993). These include visual and perceptual skills, together with motor skills and cognitive processes. The juxtaposition between age and crash risk is rather difficult as several factors need to be considered (i.e. driver behaviour, situation, model of vehicle and exposure) (Allen et al., 2019a; Casutt et al., 2014; Cicchino & McCartt, 2014; Donorfio et al., 2008, 2009; Stalvey et al., 2000). While these changes are well documented within research on ageing adults, the extent to which these declines occur, as well as the degree to which they affect life, is not ubiquitous.

South Africa, like other countries across the world, has stipulated conditions that inform the issuing of driving licenses (Asbridge et al., 2017; Dipuo, 2014; New Zealand-Government, 2020; Road Traffic Management Corporation & Department of Transport, 2018; The Automobile Association Of South Africa, n.d.; Thomas et al., 2014; Transport, 2016). Specific legislation will be highlighted later in this review; however, examples of factors that may affect driving ability are covered below.

To bring context to the points made in the paragraph above, these three topics of concern will be discussed in more detail: visual defects, motor function and cognitive decline.

The ageing process brings about changes in vision as well as a deterioration of the structural integrity of the eyes (Amod, 2007; Chader & Taylor, 2013; Pilz et al., 2015; Salvi et al., 2006). The eyes are sense organs that detect external signals, which are then relayed to the brain for processing (Chader & Taylor, 2013; Pilz et al., 2015;

Wigham & Y, 2013). These age-related declines in vital human senses occur gradually and become more overt with the latter parts of adulthood (Chader & Taylor, 2013; Cox et al., 2014; Tallis, 1993). The importance of vision with respect to driving is reiterated throughout the literature, both old (Ball et al., 1993) and more recent (Agramunt et al., 2018; Allen et al., 2019; Chader & Taylor, 2013; MacLeod et al., 2014). It would seem as though the role of visual perception, more so the specific function of vision prominently used in tests performed before the issuing of a driver's license (i.e visual acuity), is seen to not be a gold standard in determining increased crash risk, or compensatory practices that ensure safe driving capabilities and practices. This is evident in literature such as that of Zhang et al (2020), Wikman et al (1998), and Allen et al (2018). From these bodies of literature, the following points can be made and therefore argued out:

Visual acuity alone is not enough to determine prominent risk factors for the targeted population of interest (adults 55+ years). Age-related deterioration in the function of the eyes is not limited to a loss in the ability to discern fine detail (visual acuity), but can also include the development of cataracts, presbyopia and glaucoma. (Agramunt et al., 2018; Chader & Taylor, 2013; Owsley et al., 2001; Wigham & Y, 2013; J. M. Wood, 2019, 2020) .

To expand further on the above-mentioned statement, glaucoma will be used to explain the importance of using various eye tests to determine eligibility to drive. Glaucoma is a gradually progressive condition that damages the optic nerve as a result of an excessive build-up of pressure in the eye. It is also a common cause of blindness in people (Barker et al., 2008; Borisov et al., 2018; Borsos et al., 2016; Brown & Laurier, 2017; Damiani et al., 2009; Eby & Kantowitz, 2006). The progression of the illness is slow and gradual, meaning that people may not realise they have the condition until much of the damage is done. This could result in visual acuity levels being within an acceptable range at licensing centres until the illness is diagnosed, and major differences can be seen (Ball et al., 1993; Foy & Chapman, 2018; Wigham & Y, 2013).

Similarly, issues such as increasing glare at night may go unnoticed as license issuing is typically conducted during the day, where glare is minimal, and as already mentioned, visual acuity is the primary function used to determine visual eligibility to

drive (Africa, 2020; Dipuo, 2014; MacLeod et al., 2014; West et al., 2003).

Perceptions around risk factors are highly subjective and need to be backed up by objective visual and cognitive function tests (Ball et al., 1993; Karali et al., 2017; West et al., 2003; Wood, 2020; Zhang et al., 2020) can be either over- or underrated (Kaye et al., 2018; Levasseur et al., 2016; Ross et al., 2012). While differences between objective and subjective measures are expected to be either in agreement or disagreement with each other, there is a phenomenon known as recall bias (Allen et al., 2019; Ang et al., 2019; Karali et al., 2017; Martinussen et al., 2014; Owsley, C; Wood, 2015). This occurs as participants may not recall circumstances, or at times, not be able to gauge the extent to which their performance ranged.

**Race:** As a historical concept, race has been used to shape and reinforce socioeconomic and political systems (Bryant et al., 2022; Gravlee, 2009; Jeremy Seekings & Natrass, 2004; Lujan & DiCarlo, 2024; Smedley & Smedley, 2005). Race is not biologically or anthropologically sound, but rather a social construct used to classify people based on physical characteristics that include skin colour, visible physical features as well as descent (Bryant et al., 2022; Gravlee, 2009; Lujan & DiCarlo, 2024; Smedley & Smedley, 2005). The concept of race as a social construct can be traced back as far as the 18<sup>th</sup> century and was used to perpetuate racial superiority and inferiority, as a result of geographical mobility that allowed people to come into contact with those who appeared to look different from themselves (Gravlee, 2009; Lujan & DiCarlo, 2024; Smedley & Smedley, 2005). This construct permeated globally and was used to alienate anyone considered to be inferior (Gravlee, 2009; Lujan & DiCarlo, 2024; Smedley & Smedley, 2005) . Constructed by Western societies, the construct of race was used to set “whiteness” as the standard and as superior (Bryant et al., 2022; Gravlee, 2009; Smedley & Smedley, 2005). This became a global tool used to justify atrocities such as slavery, and in South Africa, apartheid (Gravlee, 2009; Jeremy Seekings & Natrass, 2004; Smedley & Smedley, 2005) .

Evolutionary biologists and anthropologists have disproved race on a biological level for several reasons. Race is not genetically distinct; there is no genetic evidence separating groups of people based on their physical appearance (Fausto-Sterling & Stein, 2004; Lujan & DiCarlo, 2024). What this translates to is that the genetic makeup of humans is so diverse that there are no boundaries that can be used to determine

racial classification, this occurs even though specific genetic material can be passed down from an ancestral lineage (Bryant et al., 2022; Fausto-Sterling & Stein, 2004; Gravlee, 2009; Lujan & DiCarlo, 2024). This means that a person presenting with fair skin and another with darker skin will have a different genetic makeup and may present similarly to those whose genes they inherited. However, there is no evidence that their genetic differences are significant enough to allow a distinct classification based on physical attributes. In essence, two people from the same racial category can be more genetically different to each other than from someone who is racially different (Duello et al., 2021; Duster, 2006; Lujan & DiCarlo, 2024).

As previously mentioned, “race” became applicable when populations from different continents came into contact with each other, and can also be fluid based on geographical location (Bryant et al., 2022; Duster, 2006; Hirschman, 2004; Howard, 2000). Irrespective of the science disproving race as a biological construct, society still uses it as a classification method (Bryant et al., 2022; Duello et al., 2021; Duster, 2006; Hirschman, 2004; Howard, 2000; Lujan & DiCarlo, 2024; Smedley & Smedley, 2005). For some members of society, the stereotypes associated with inferiority and superiority complexes associated with race persist and are also used as a diagnostic tool to place people in different social classes (Gravlee, 2009; Howard, 2000; Jeremy Seekings & Natrass, 2004). It has become acceptable to use race to identify people in South Africa, and it is used today to distinguish people based on skin colour (Jassat et al., 2022; Jeremy Seekings & Natrass, 2004).

**Sex:** Often mistaken for gender, sex is a biological construct used to distinguish between males and females (Arnegard et al., 2020; Fausto-Sterling & Stein, 2004). The distinction is made based on the types of chromosomes present, reproductive organs, and hormonal composition (Bale & Epperson, 2017; Bergdahl, 2005; Bhargava et al., 2021; Fausto-Sterling & Stein, 2004).

Gender, on the other hand, is far more complex and is highly dependent on social constructs and cultural exposure (Bhargava et al., 2021; Fausto-Sterling & Stein, 2004; Giuliano, 2020; Lindqvist et al., 2021; Martin & Ruble, 2010). Unlike sex, gender is non-binary and encompasses social, cultural, behavioural and psychological aspects which define identity (Fausto-Sterling & Stein, 2004; Giuliano, 2020; Lindqvist et al., 2021; Martin & Ruble, 2010). Behaviours and expectations as dictated by

sociocultural norms (i.e. gender) are often tied to specific sexes (Bhargava et al., 2021; Fausto-Sterling & Stein, 2004; Giuliano, 2020; Lindqvist et al., 2021; Martin & Ruble, 2010). Thus, it is important to understand not only the differences between sex and gender but also how they interact or overlap.

It is by understanding the differences between sex and gender that gender roles can be defined. Gender roles are socially and culturally created expectations, behaviours and responsibilities that society ascribes to people based on their biological sex and perceived gender (Bale & Epperson, 2017; Fausto-Sterling & Stein, 2004; Giuliano, 2020; Lindqvist et al., 2021; Martin & Ruble, 2010). Historically, both in the Western world and in South Africa, gender roles have been shaped and influenced by patriarchal systems and structures wherein women were disadvantaged compared to men (Eagly, 1987; Giuliano, 2020; Rodriguez & Guenther, 2022). Under Apartheid South Africa, however, gender roles were compounded by racial and gender discrimination (Giuliano, 2020; Seekings & Natrass, 2004; Pellicer & Ranchhod, 2023).

#### 2.4.2 The Technical Subsystem

By definition, the technical subsystem within a socio-technical system comprises the non-human, technological and mechanical components, enabling the system's overall functionality (Biehler et al., 2008; Carayon, 2006; Kahlen et al., 2016). In the context of the human-car-road system, the technical subsystem comprises vehicles (both that of a singular driver and those of other road users), road infrastructure, traffic control procedures and enforcement, and finally, technology aimed to enhance driving safety and efficiency (Oosthuizen & Pretorius, 2016; Oosthuizen & Wout, 2019; Righi & Saurin, 2015; Saurin & Gonzalez, 2013). These all play a key role in influencing driver behaviour and related road safety effects.

The world's technological advances did not come singlehandedly but also brought with them social and cultural shifts. As a result, we have seen progressive changes and advancements being made to cars (Borisov et al., 2018; Damiani et al., 2009; Dols et al., 2020; Risto et al., 2017). The criteria used by modern-day society when choosing a car have expanded beyond the basics of reliability and functionality (Borisov et al.,

2018; Borsos et al., 2016; Damiani et al., 2009; Risto et al., 2017). Instead, the criteria now include factors such as aesthetics, performance, fuel efficiency, parking assistance and much more (Borisov et al., 2018; Borsos et al., 2016; Damiani et al., 2009; Risto et al., 2017). As technology continues to advance, so does the automotive industry strive to keep up with the latest technologies, not only to enhance safety and performance but also to increase comfort while driving, as well as to present relevant information required by the driver to successfully carry out the act of driving (Borisov et al., 2018; Damiani et al., 2009).

Perception, particularly visual perception, is paramount to the task of driving. The driver is exposed to stimuli from both inside and outside of the vehicle. While technological improvements and inventions are being created to improve cars and the driving experience, the social subsystem, or the human, is still largely accountable for safety and other interactions between the two subsystems (Brown & Laurier, 2017; Coxon et al., 2017; Levasseur et al., 2016)

## **2.5 The Road and Road Infrastructure**

It is important to note that in this research project, we refer to the road not only as the physical surface upon which cars are driven. However, it subsequently includes the design of the road, road geometry, road signs, as well as the extended road traffic system, not excluding the role and the presence of other road users (Barker et al., 2008; Borsos et al., 2016; Dommès et al., 2015; Salmon et al., 2010) . In essence, the complex environment. The road, vehicle, and road user (driver) interactions inform and reflect on road traffic safety (Dommès et al., 2015; Eby & Kantowitz, 2006; Risto et al., 2017).

The ideal road system is one where users know how to behave intuitively based on the design of the road (Lee et al., 2019; Biehler et al., 2008; Brown & Laurier, 2017; Eby & Kantowitz, 2006; Koppel et al., 2016). What this translates to is that, theoretically speaking, the “perfect” road is one where the road infrastructure itself informs the human operator of the intended general flow and movement of the vehicle along the road network system (Biehler et al., 2008; Eby & Kantowitz, 2006). This would negate the need for road signs and speed limits as the driver’s behaviours would

coincide with the particular characteristics of the road at a given time (Biehler et al., 2008b; Eby & Kantowitz, 2006). This, however, may not be the case.

Driving rules and regulations also form part of the complexity that is found between the interactions between the complex environment, the social subsystem, the effectiveness of performing the task, and ultimately the technical subsystem (Barker et al., 2008; Biehler et al., 2008; Republic of South Africa: Government Gazette Staatskoerant, 2014) .

Driving legislation in South Africa is governed by the National Road Traffic Act, 1996 (ACT NO. 93 OF 1996) (Dipuo, 2014; Republic of South Africa: Government Gazette Staatskoerant, 2014). The Act states as follows: “To provide for road traffic matters which shall apply uniformly throughout the Republic and for matters connected therewith”(Republic of South Africa: Government Gazette Staatskoerant, 2014) . Concerning this research project, sections 13 and 15 will give relevant insight into what criteria are used to ensure that one is eligible for a valid driver’s licence.

A section of this legislation is provided below. The reason is that it highlights exclusionary criteria for the issuing of a valid driver’s license. As mentioned in section 2.4.1, within the social subsystem, driving behaviours are influenced by factors such as laws and policies. Mentioning the regulations associated with driving in South Africa elucidates the relationship between age-related changes as well as behavioural aspects that inform driving habits, perceptions and practices. These are linked to the social subsystem and are important in the interaction of the two subsystems. While the law may be clearly defined and laid out, the application thereof in South Africa may not always be correctly or fully implemented (Traffic Focus, 2012; Transport, 2016) . This is evident as the country continues to battle with tackling issues of corruption amongst those employed by the Department of Transport (Schermers et al., 2019; Transport, 2016). The social implications of this are broad, as they not only affect the two subsystems but also affect the task of driving and the importance of safe and efficient driving. This ultimately affects the environment within which the system acts.

The legislature highlights specific constraints that are in line with the demographic of choice used in this study. Particularly, conditions that are age-related and likely to cause ineligibility to obtain a license.

Section 13, subsections a) and b) states as follows: (Republic of South Africa: Government Gazette Staatskoerant, 2014) *“A licence authorising the driving of a motor vehicle shall be issued by a driving licence testing centre in accordance with this Chapter and shall be either-*

*a) provisional licence, to be known as a learner’s licence; or*

*b) a licence, to be known as a driving licence,*

*and, except as otherwise provided in this Chapter, no person shall be examined or tested for the purpose of the issue to him or her of a driving licence unless he or she is the holder of a learner’s licence. “.*

*a) provisional licence, to be known as a learner’s licence; or*

*c) a licence, to be known as a driving licence,*

*and, except as otherwise provided in this Chapter, no person shall be examined or tested for the purpose of the issue to him or her of a driving licence unless he or she is the holder of a learner’s licence. “.*

*Furthermore, section 15 of the act details the criteria that disqualify one from obtaining or holding a valid driver’s licence (NPO Act71 of 1997(1), 2014), sub-section 1, paragraphs b to h state as follows (NPO Act71 of 1997(1), 2014) : “A person shall be disqualified from obtaining or holding a learner’s or driving licence-*

*b) during any period in respect of which he or she has been declared by a competent court or authority to be disqualified from obtaining or holding a licence to drive a motor vehicle, while such disqualification remains in force;*

*c) where a licence to drive a motor vehicle held by him or her has been suspended by a competent court or authority, while such suspension remains in force;*

*d) where a licence to drive a motor vehicle held by him or her has been cancelled by a competent court or authority, for such period as he or she may not apply for a licence;*

*e) if such licence relates to a class of motor vehicle which he or she may already drive under a licence held by him or her;*

*f) if he or she is suffering from one of the following diseases or disabilities:*

*(i) Uncontrolled epilepsy; 10*

*(ii) sudden attacks of disabling giddiness or fainting due to hypertension or any other cause;*

*(iii) any form of mental illness to such an extent that it is necessary that he or she be detained, supervised, controlled and treated as a patient in terms of the Mental Health Act, 1973 (Act No. 18 of 1973); 15*

*(iv) any condition causing muscular incoordination;*

*(v) uncontrolled diabetes mellitus;*

*(vi) defective vision ascertained in accordance with a prescribed standard;*

*(vii) any other disease or physical defect which is likely to render him or her incapable of effectively driving and controlling a motor vehicle of the 20 class to which such licence relates without endangering the safety of the public: Provided that deafness shall not of itself be deemed to be such a defect.*

*g) if he or she is addicted to the use of any drug having a narcotic effect or the excessive use of intoxicating liquor; or.*

*h) 25 in such other circumstance as may be prescribed, either generally or in respect of a particular class of learner's or driving licence”.*

From the above expert of the legislature, demographic-specific constraints concerning age include disease and disability. An additional social implication is substance abuse. For the purpose of this research, the diseases and disabilities mentioned specifically will be the focus. It is recommended that any other constraints be explored in future research, as they fall beyond the scope of this research project.

## **2.6 Contextualising the Socio-Technical System**

As a complex socio-technical system (Carayon, 2006; Walker et al., 2010) the human driver interacts with other vehicles and the road infrastructure within a broader social context that includes the influences of interpersonal relationships, societal views and norms, as well as legal and regulatory structures. The system functions as an

integrated network wherein mobility in the form of driving is expected to happen safely, effectively and efficiently (Hollnagel, 2014). Within the context of this research, the task of driving is set within the Gauteng province. A province characterised by frequent traffic congestion, multiple high-speed highways or freeways, all of which are characterised by the urban environment (Antoun et al., 2018; Cervero, 2013; McCarthy, 1990; Oosthuizen & Pretorius, 2016).

Existing in Gauteng are both urban and peri-urban road infrastructure and systems (Africa et al., 2021; Khosa', 1995; McCarthy, 1990; Moyo et al., 2021). Driving in Gauteng poses unique challenges, such as a high prevalence of public transportation, particularly minibus taxis, disparities between road infrastructure as seen in urban and peri-urban areas, together with various walks of life that characterise the need for mobility (Jeremy Seekings & Nattrass, 2004; Khosa', 1995; McCarthy, 1990; Moyo et al., 2021; Oosthuizen & Pretorius, 2016; Pellicer & Ranchhod, 2023; Schermers et al., 2019). These challenges require great decision-making skills and experience (Khosa', 1995; Moyo et al., 2021; Schermers et al., 2019). Understanding demographic interactions within the human-car-road system in Gauteng is important for safe and efficient driving.

Ageing adults, in comparison to their younger counterparts, albeit driving in the same spaces, experience different driving-related challenges based on experience, external social influences, learned behaviours and socioeconomic disparities (Africa et al., 2021; Allen et al., 2019; Antoun et al., 2018; Cervero, 2013; Seekings & Nattrass, 2004; Khosa', 1995; McCarthy, 1990; Raitanen et al., 2003; Rhodes & Pivik, 2011). For example, driving-related research has indicated that there may be sex-related differences in risk-taking behaviour. Older male drivers have been known to take greater risks than their female counterparts (Allen et al., 2019; Møller & Gregersen, 2008; Sullivan et al., 2011; Ulleberg & Rundmo, 2003; Wang et al., 2020).

## **2.7 Emergent Behaviour**

The complexity of socio-technical systems and their related uncertainties warrant a straightforward approach to aiding the analysis and comprehension of the many systems-related problems (Kahlen et al., 2016; Larsson et al., 2010; Wilson, 2014; Wood et al., 2016). Emergence as a concept is one of the feature-defining aspects of a system (Cohen, 2012; Kahlen et al., 2016; Righi & Saurin, 2015; Saurin & Gonzalez,

2013; Wilson, 2014; Wilson & Carayon, 2014). Before delving into defining the term “emergence”, we have chosen to expound on the characterisation of systems behaviour. Reiterating what has already been mentioned, at its core, the system consists of several interacting parts (Larsson et al., 2010; Oosthuizen & Wout, 2019; Walker et al., 2010). These parts ought to be optimised or at least be satisfactory in their unified interactions for the benefit of the broader system (Baxter & Sommerville, 2011; Guastello, Stephen, 2018; Kahlen et al., 2016; Larsson et al., 2010; Wilson, 2014). Our attempts at better understanding emergence require that we draw parallels between system behaviour and emergence.

The information presented in this literature review, from our understanding, means that we can start making inferences as we put things into context. Based on the repetitiveness in the literature regarding systems, it is indeed factual that systems are designed with a specific purpose and outcome(s) in mind. These purposes or ideal outcomes are what we call the behaviour of the system. Literature (Baxter & Sommerville, 2011; Borisov et al., 2018; Kahlen et al., 2016; Larsson et al., 2010; Lee & Itoh, 2020; Saurin & Gonzalez, 2013; Siemieniuch & Sinclair, 2014; Wilson, 2014) and researchers who are focused on a systems discipline seem to share the consensus (Kahlen et al., 2016; Kopetz et al., 2016; Mittal & Rainey, 2015; Szabo & Birdsey, 2017; Wilson, 2014) that systems behaviour can be predicted or unpredictable, furthermore, they can be desirable or undesirable. A key point to note is that these behaviours are not mutually exclusive; examples of this can be consolidated in the literature (Carayon & Perry, 2021; Hettinger et al., 2015; Saurin & Gonzalez, 2013; Wang & Wells, 2020).

As an integrated system comprising social and technical components to achieve the goal of safely and efficiently driving from one place to another, the human-car-road system will be argued by making use of systems behavioural concepts and emergence concepts. Figure 2 may be used as a reference point.

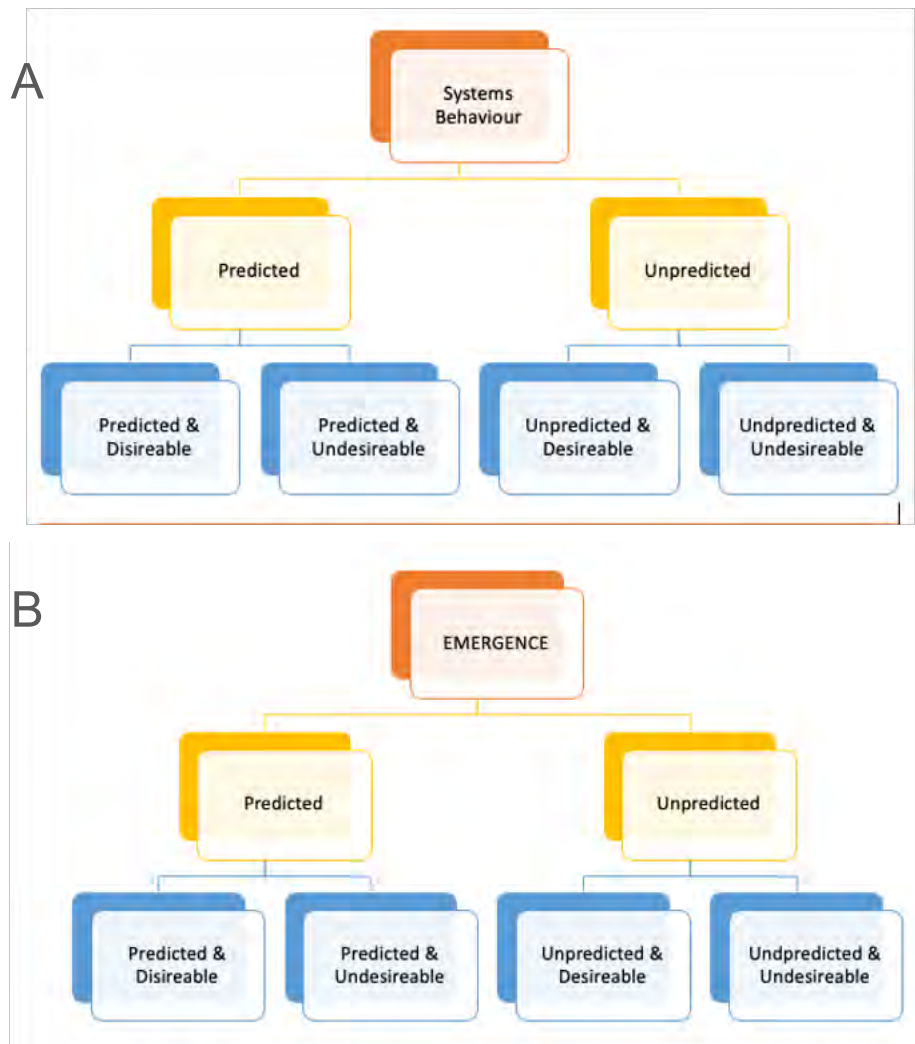


Figure 2: (A) A Breakdown of Systems Ergonomics Theory (Szabo et al., 2019); (B) A breakdown of Emergence Ergonomics Theory (Szabo et al., 2019; Szabo & Birdsey, 2017)

Figures 2A and 2B above show the similarities that can be drawn between systems behaviour and emergence. As can be seen in Figure 2, systems behaviour can be either predicted or unpredicted. Behaviours can branch out further (Kahlen et al., 2016) under the main characteristics of predictability (both predictable and unpredictable). After predictability, desirability becomes a factor.

Figure 2A (Kahlen et al., 2016) branch 1 shows a systems behaviour that is predictable; this behaviour is what the designers of the system would expect. The

predicted and unpredicted behaviour are errors or challenges that are expected as part of the systems design. Branch 2 illustrates how systems behaviour can conversely also be unpredicted. As is the case with predictable behaviour, unpredictable behaviour can also be further divided into 2 separate branches. Namely, the unpredicted and desirable or the unpredicted and undesirable (Kahlen et al., 2016)

These unpredicted behaviours commonly occur due to (Guastello, Stephen, 2018; Kahlen et al., 2016; Righi & Saurin, 2015) oversight during the design process, unpredicted yet desirable behaviours may positively occur. They positively affect the end goal of the system, beyond what the system designers could have seen or imagined (Carayon et al., 2015; Guastello, Stephen, 2018; Kahlen et al., 2016). This could be the pleasant outcome of reductionism, as sub-system designs may positively affect how the system at large responds to the altered interactions between the different system components. Unpredicted and unpleasant behaviour, however, may pose a challenge that adversely impacts the goal of the system. These are major unforeseen problems that may be costly. These behaviours are the result of not properly understanding the broader sociotechnical system holistically.

Emergence refers to the process whereby complex systems and patterns arise from simpler system components (Mittal & Rainey, 2015; Szabo et al., 2019; Szabo & Birdsey, 2017). Based on the information provided in section 2.4 of this literature review, emergence within the human-car-road system should highlight the interdependent and adaptive nature of driving behaviour and road infrastructure (Mittal & Rainey, 2015; Szabo et al., 2019; Szabo & Birdsey, 2017). Understanding these two factors would play a pivotal role in informing the design of well-functioning road network systems, informing policymakers and law enforcement on possible interventions that should be made and overall ensuring that safe and efficient driving is possible. Theoretically speaking, if the human-car-road system were conceptualised to be “perfect”, then we could have a well-running system where all things could be predicted, including the predicted and undesirable (these would be trade-offs).

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It is important to address the literature that was used to inform this particular research project. Age is a pivotal factor in this research project as it informs the type of participants recruited. Ageing, as previously mentioned, is associated with particular biological declines. However, given that the social aspect of the sociotechnical subsystem also comprises other human beings, it cannot be ignored that the participants have to relate with other people, be they other drivers, friends, relatives, or the broader society (Ang et al., 2020; Antoun et al., 2018; Gwyther & Holland, 2012; Sullivan et al., 2011) . It is by and large these interactions within the social subsystem that affect the task of driving and the behaviours associated with it (i.e. habits, practices and perception).

When focusing on the human aspect of this project, because of our target audience being of a certain age, we expect certain events to occur. For example, a 65-year old male who has over 40 years of driving experience may find himself in a position where his response time is slower; however, he may be able to manoeuvre a challenging situation (e.g. someone speeding towards him at a sharp bend) far quicker than a novice driver. This can be done by either creating enough distance, avoidance or slowing down (i.e. situation dependent).

While we do address certain medical conditions in this review of literature, we do not mention all possible illnesses that may affect driving and are therefore aware that the presence of other illnesses has the potential to affect driving behaviours and patterns (Abdelkarim et al., 2017; Allen et al., 2019; Ang, Jennifer, et al., 2019; Hollnagel, 2014; Konstantopoulos et al., 2010; MacLeod et al., 2014; Martinussen et al., 2014; Wagner et al., 2011). Self-regulation requires awareness of risk factors that could negatively

impact task performance (Abdelkarim et al., 2017; Amarya et al., 2018; Dommes et al., 2015; MacLeod et al., 2014; Sargent-Cox et al., 2011; Wagner et al., 2011) . Thus making basic health literacy beneficial for drivers to better understand the dynamics of increasing age or an increased prevalence of degenerative illness, to better inform their own practices (Amarya et al., 2018; Ang et al., 2020; Ang et al., 2019; Cantin et al., 2009; Conlon et al., 2017; Dickerson et al., 2019; Donorfio et al., 2008, 2009; MacLeod et al., 2014; Molnar et al., 2014; Sargent-Cox et al., 2011; Wagner et al., 2011).

Having discussed the intricacies of what constitutes a sociotechnical system and subsequently characterising the elements thereof, a mapping of the behaviours of the system can be contextualised. Table 2 comprises a list of references used to achieve this.

Table 2: Literature Used to Map Expected System Outcomes

| Title   | Reference               |
|---|-------------------------|
| Self-perceptions and Current Practices of High-risk Older Drivers: Implications for Driver Safety Interventions         | (Stalvey et al., 2000)  |
| Visual risk factors for crash involvement in older drivers with cataract  | (Owsley et al., 2001)   |
| Older drivers' self-assessed driving skills, driving-related stress and self-regulation in traffic                      | (Siren & Meng, 2013)    |
| The relation between performance in on-road driving, cognitive screening and driving simulator in older healthy drivers | (Casutt et al., 2014)   |
| Why do older drivers reduce driving? Findings from three European countries   | (Raitanen et al., 2003) |
| Nighttime driving: visual, lighting and visibility challenges   | (J. M. Wood, 2020)      |
| Sex differences in attitudes toward driving: A survey   | (Bergdahl, 2005)        |
| Age and gender differences in risky driving: The roles of positive affect and risk perception                           | (Rhodes & Pivik, 2011)  |
| Self-rated driving and driving safety in older adults   | (Ross et al., 2012)     |

|   |  |
|---|--|
| Driving concerns among older adults: Associations with driving skill, behaviours, and experiences   | (Allen et al., 2019)                                 |
| Older adults' safety perceptions of driving situations: towards a new driving self-regulation scale   | (Sullivan, Karen A.; Smith, Simon S; Horswill, 2011) |
| Driving a better driving experience: a questionnaire survey of older compared with younger drivers  | (Karali et al., 2017)                                |
| Driving task: How older drivers' on-road driving performance relates to abilities, perceptions, and restrictions                            | (Koppel et al., 2016)                                |
| Sensitivity and specificity of the safe driving behavior measure and the driving habits questionnaire for older self-drivers                | (Kim et al., 2016)                                   |
| Driving cessation and health outcomes in older adults   | (Chihuri et al., 2016)                               |
| The challenge of safe driving among elderly drivers   | (Albert et al., 2018)                                |
| Driving cessation and health trajectories in older adults   | (Edwards et al., 2009)                               |
| Factors and challenges of driving reduction and cessation: A systematic review and meta-synthesis of qualitative studies on self-regulation | (Ang et al., 2019b)                                  |
| Driving in an urban environment, the stress response and effects of exercise  | (Antoun et al., 2018)                                |

Based on the literature explored, a trend among ageing adults is to modify their driving behaviour or to self-regulate their driving behaviour (Ang et al., 2020; Devlin & McGillivray, 2014; Gwyther & Holland, 2012; Siren & Meng, 2013). This is most frequently a consequence of physical and cognitive decline (Brelet et al., 2016; Donorfio et al., 2008; Sullivan et al., 2011), and occurs across various age groups, sexes, and races.

Self-regulation refers to the voluntary changes or altered practices adopted by drivers. This usually occurs in the form of either avoidance or limitation (Agramunt et al., 2018b; Ang et al., 2020; Ang, et al., 2019; Ang, Oxley et al., 2019; Brelet et al., 2016; Conlon et al., 2017; Dickerson et al., 2019b; Donorfio et al., 2008, 2009; Levasseur et

al., 2016; Molnar et al., 2014). There are many ways that ageing or elderly drivers may choose to adapt their driving. Drivers may, for various reasons, avoid certain driving situations (e.g. driving at night), limit the frequency of their driving, or perhaps even stop driving altogether. Self-regulation is brought on by the awareness of intrinsic and extrinsic factors that may contribute to increased driving-related risk (Allen et al., 2019; Donorfio et al., 2009; Jouk et al., 2014; Owsley, 2016; Sargent-Cox et al., 2011; Stalvey & Owsley, 2000; Sullivan et al., 2011; Wong et al., 2016; Wood et al., 2018).

These factors include, but aren't limited to: increasing health concerns, cognitive decline, concerns from friends/family, living arrangements, access to alternative sources of transportation, etc. (Allen et al., 2019; Ang et al., 2019a; Ang et al., 2019; Conlon et al., 2017). As mentioned in the literature review, the purpose of this research project is to investigate how age, sex and race influence driving habits, perceptions and practices. Based on the research explored in the review of the literature (Bowling, 2011; Cantin et al., 2009; Chihuri et al., 2016; Kaye et al., 2018; Levasseur et al., 2016; Owsley et al., 2001; Stalvey & Owsley, 2000). It is expected that drivers who are more aware of their age-related impairments will modify their driving practices to compensate for those impairments. The more impairments there are, the more modifications there will be. It is also expected that differences in age groups, sexual differences (societal norms included), and race (societal norms included) will be observed.

The research suggests that although self-regulation occurs across various age groups, adults over the age of 70 are likely to voluntarily reduce driving exposure or cease driving completely, as opposed to their younger counterparts (Marottoli & Richardson, 1998; Molnar et al., 2014; Raitanen et al., 2003). These voluntary self-regulatory changes can be driven by several factors, such as access to alternative transport and the need for mobility (Donorfio et al., 2008, 2009; Gwyther & Holland, 2012; Sargent-Cox et al., 2011). Going back to the sociodemographic and sociocultural factors discussed at length in this review, it has been noted that urbanisation and spatial planning greatly affect people's mobility. The stark differences in road infrastructure, access to safe and reliable transportation and socioeconomic factors such as income status can create complex issues which trickle down into the need for mobility. It could be expected that individuals of lower income may need to continue driving, despite their own intrinsic need or desire to self-regulate.

The social influence and needs of loved ones could require someone to continue working. Based on the type of area they live in, this may affect the amount of time they spend on the road, the weather, daytime and nighttime conditions and lastly traffic. These factors are across the lines of age, sex and race.

Sex-based differences in driving behaviour are well-documented in driving-related literature (Bergdahl, 2005; Eagly, 1987) . It has been highlighted that in comparison to their female counterparts, males are more likely to perceive particular driving scenarios as less risky, resulting in increased risk-taking behaviour (Lee & Itoh, 2020; Møller & Gregersen, 2008; Rhodes & Pivik, 2011; Ulleberg & Rundmo, 2003) . Men have also been reported to self-regulate less as a means to maintain independence. This behaviour is persistent even with a decline in the ability to drive, whereas women will restrict their driving practices even before significant functional declines (Lee & Itoh, 2020; Ram & Chand, 2016; Rhodes & Pivik, 2011).

Based on all the literature reviews, it could be posited that self-regulatory driving behaviours are emergent characteristics of the interplay between the socio-technical system. However, the degree to which that happens may be unclear, particularly when it comes to South Africa's unique socioeconomic and sociocultural dynamics.

## **CHAPTER 3: METHODS**

### **3.1 Background Informing Research Design**

There are various options that people use to commute between places. Driving is but one of the forms of on-land transportation used by a vast number of people across the world. The aims of this study are two-fold. Namely, to identify the habits, perceptions and practices of ageing South African drivers based on race, age and sex. The secondary aim was then to investigate the role played by the ageing South African driver within the human-car-road system, by making use of systems ergonomics principles.

Stereotypically, elderly drivers may be perceived to be a cause for concern where driving safety is of interest (Ball et al. 1993; Conlon et al., 2017; Gugerty, 2011; Stalvey et al., 2000). The mobility of the elderly driver, by means of driving, is of great importance, as it positively affects independence and self-worth (Conlon et al., 2017; Donorfio et al., 2009; Stalvey et al., 2000). The process of ageing or senescence, as discussed in the review of literature, is accompanied by increased functional impairments and a general decline in health and performance of the basic sensory functions required for driving (i.e. vision, cognitive function, information processing, and motor function (Amod, 2007; Anstey et al., 2012; Bishop et al., 2010; Hayflick, 2000; Lee & Cheng, 2008) .

### **3.2 Research Design**

This research project followed a cross-sectional design, where participants were sourced within the Gauteng province. Given the attention that would be directed to demographic information to answer the research question, as well as the opportunity to compare this study with previous work conducted by the likes of Owsley and Stalvey (2000), this design seemed more appropriate. Recruited participants included neighbours, community members, family members, colleagues and associates and parents' learners from a local high school (Hoërskool Drie Riviere). Additionally, participants made others aware of the study by word of mouth. The questionnaires

were used to obtain subjective responses from adults 55 years+ regarding the relationship between their ageing and the task of driving.

### 3.3 Participant Sampling

Participants were sought out within the Gauteng province. This was due to COVID-19-related travel restrictions. To determine the sample size, relevant and up-to-date statistics on licensed drivers within Gauteng were researched (Road Traffic Management Corporation & Department of Transport, 2018) .

#### 3.3.1 Calculation of Sample size

The Gauteng population is 15 176 116, of that population, 4 718 545 (Road Traffic Management Corporation & Department of Transport, 2018) were licensed drivers (this figure excludes the percentage or number of people unlicensed, as well as those with expired licenses. It is important to note that the figures obtained may not have been conservative. Below are the calculations used to determine the sample size (Watkins, 2017) .

#### Infinite population size calculation

$$SS = \frac{Z^2 \times p(1-p)}{C^2} \quad \therefore \quad SS = \frac{1.96^2 \times 0.5(1-0.5)}{0,05^2}$$

$$SS = 196$$

#### Adjustment for finite population

$$SS = \frac{SS}{1 + \frac{SS - 1}{N}} \quad \therefore \quad SS = \frac{196}{1 + \frac{196 - 1}{4718545}}$$

SS =195, 99 which is rounded off to 196 people.

Where:

SS is sample size

Z is Z-score

C is margin of error

P is standard deviation

N is population size

Based on these calculations, for questionnaires to be statistically valid, a minimum of 196 participants were required to complete the questionnaires (Watkins, 2017) .

### 3.3.2 Participant Characteristics

Participants recruited comprised both males and females (biological sex) aged 55 years and older. Participants recruited had to have a valid driver's licence or be a previously licensed driver. Participants could be of any race, any education level, or any socioeconomic status. In the case of previously licensed drivers, participants were excluded if their driver's license had at any time been revoked through a court order.

### 3.3.3 Participant recruitment

Roughly 220 questionnaires were printed and distributed to neighbours and family members to hand out to their peers. All COVID-19 regulations were in place for the distribution of the questionnaires. These included the wearing of masks, social distancing and periodic sanitising of equipment used (e.g. pens and clipboards. The option for Zoom meetings was also made available to participants who were not comfortable meeting in person. Questionnaires were also distributed to staff and

parents at a local High School within the province of Gauteng, specifically the suburb of Three Rivers East. Those who fit the criteria and were willing to partake in the study were given a verbal explanation of the project, and a participant information letter detailing the description of what the research was about. Participants gave both verbal and written consent (Appendix A4). Participants were also informed that they could withdraw from the study with no repercussions.

#### 3.3.4 Ethics

Before participant recruitment, ethical clearance was obtained from Rhodes University's Ethics Committee (Approval number: 2021-1599-5931). This information is included in Appendix A1. For private businesses and schools, a permission to conduct research letter was presented to them, and they could sign off if they were willing to have their spaces used for the questionnaire. For the permission approval letter, please see Appendix A2.

### 3.4 Questionnaires

To effectively address the aims of this research project, it was important to identify appropriate research tools that would adequately identify the driving behaviours of South African adults concerning race, sex and age. This study employed two key research instruments: the Driver Habits Questionnaire (DHQ) and the Driver Practices and Perceptions Questionnaire (DPPQ). These standardised tools are widely used in driving research to assess habitual driving tendencies, self-rated fitness, and adaptations made in response to age-related changes (Classen et al., 2012; Kaye et al., 2018; Song et al., 2015). Additionally, a participant demographic information sheet was used to capture key information such as age, race and sex.

The DHQ provided insight into the frequency of specific behaviours, while the DPPQ explored drivers' self-perceived skills, interactions with road infrastructure, and external influences such as technology, infrastructure and road safety regulations. By incorporating these measures, the study ensured a comprehensive assessment of the human-car-road system within an ageing driver population, facilitating a nuanced

understanding of demographic influences on driver behaviour in the South African context.

#### 3.4.1 Participant Details form

This information sheet (Appendix A5) was created to obtain relevant demographic data from each participant. This information was required to allow similarities and differences identified in the results section to be clear, and to aid the completion of both the data analysis and the discussion. Secondary to that, it required participants to give responses regarding their own driving capabilities, prior to filling out the additional two questionnaires (see Appendices A6 and A7). The primary demographic information required was age, sex and race. Secondary to that, employment status, education level and regions of residence were also required, as that information was later used to identify the interactions within the sociotechnical system. General questions about health, driving ability and perceptions about the two were also required.

#### 3.4.2 Driver Habits Questionnaire (DHQ)

The DHQ was used to identify routine behaviours, individual practices and avoidance patterns (Lajunen & Summala, 1995). The DHQ gives insight into habitual behaviours as reported by participants, giving the researcher an idea of how the driver typically acts while driving. With the focus being on habits, the researcher can identify routine practices, behaviours and avoidance patterns.

The Driver Habits Questionnaire (DHQ) is a widely used self-report instrument designed to assess the habitual driving behaviours of individuals. It evaluates numerous aspects of driving, including exposure to different road conditions, engagement in risky driving practices, and self-regulation strategies adopted in response to age-related changes. The DHQ is instrumental in ageing driver research as it provides insight into how older adults adapt their driving habits over time.

The DHQ is a 34-item questionnaire, which was adapted into a 30-item questionnaire. One of the factors was the unexpected COVID-19 pandemic, which limited mobility during data collection. Amendments were made to the questionnaire not only to make

it applicable to the South African ageing driver road-specific context, but also to take into consideration the limited mobility (lockdown restrictions) as a result of the pandemic. Amendments made included the removal of 4 items as well as changes that would better suit South Africans (i.e. using the metric system as well as taking into consideration the side of the road on which we South Africans drive).

This questionnaire in particular provided information on driving exposure, driving space and driving avoidance. The Questionnaire is set up in a manner where respondents answer questions by reporting “Yes” or “No” Driving exposure was measured by asking participants to report. Furthermore, Likert scales were also used for different sections of the questionnaire.

*a. Current driving:*

This section of the questionnaire informed current driving habits. Questions 1,4, and 8 make use of a Yes/No response, while questions 5,6,7,9 and 10 make use of Likert scales. Questions 2 and 3 give open-ended answers that can be analysed thematically

*b. Exposure:*

Questions 12-16 were omitted for reasons previously mentioned, while question 11 provided room for responses of any number between 1-7.

*c. Avoidance:*

Where avoidant behaviours were recorded (questions 17-24), participants either responded with “Yes” or “No”. Respondents who selected “No” were then asked if visual problems had anything to do with their avoidant behaviours or not. When participants responded “Yes”, follow-up questions were recorded using a Likert scale.

*d. Crashes and Citations:*

Participants were required to give responses on their accident rates and the number of traffic fines received.

*e. Driving Space*

In the final section of the questionnaire, participants responded to where they had frequently driven within the past year.

Analysis and interpretation of the results from the DHQ were derived employing descriptive statistics. Within the different sections of the questionnaire, frequent habits were noted for the different responses based on age, sex, and race. Thus giving the researcher the necessary information to understand prevalent responses between the three mentioned variables above (age, sex and race).

### 3.4.3 Drivers Perceptions and Practices Questionnaire (DPPQ).

The Drivers' Perceptions and Practices Questionnaire (DPPQ) is a self-reported instrument designed to gather information on various aspects of driving, such as current practices and perceptions. The purpose of the tool is to collect information about drivers' self-reported behaviours, attitudes and perceptions, to better understand how these can affect road safety culture. This questionnaire provides valuable insights into how drivers perceive their own abilities, the risks associated with driving, and the external factors that influence their behaviour on the road. The DPPQ is useful in ageing driver research, as it encapsulates the cognitive and perceptual adjustments that older drivers make in response to physical and cognitive changes.

The DPPQ is a 40-item tool created by Stalvey and Owsley (2009) to supplement well-studied literature and theoretical models about health behavioural changes (Stalvey et al., 2000). Adaptations were made to the questionnaire by removing the section on "helping relationships". Participants were required to give responses to all original questions from the questionnaire. The questionnaire is divided into 6 distinct topics, namely: Impact of vision on driving, Concern for health and safety, Attitudes towards driving, perceived barriers, helping relationships and stages of change (Stalvey et al., 2000). Participants were requested to fill out six sections of the questionnaires. Responses were given by use of a Likert scale where 1- Strongly Agree, 2- Agree, 3- Disagree, 4- Strongly Disagree.

As a tool, the DPPQ can be used to distinguish demographic-related differences within how cohorts of a population's practices, perceptions and attitudes. The use of the DPPQ in combination with the DHQ was used with the hopes that they would complement each other. To expound on that, it was believed that by understanding the practices and perceptions that drivers have towards driving and general commuting (DPPQ), it would be easier to identify patterns of behaviours and habits carried out by

drivers (DHQ) and overall create a better picture of what different demographics of drivers may have in common.

This questionnaire can be found in Appendix A7. This research tool focused on the following spheres: general knowledge about driving, health and safety concerns, attitudes towards driving, the pros and cons of self-regulatory practices, as well as their subsequent strategies and lastly performance regarding the said regulatory practices. Analysis of the data obtained from this questionnaire relied heavily on demographic information such as age, sex, and race. A subgroup analysis was used to analyse this data, based on the above-mentioned demographic information.

### **3.5 Data Processing and Analysis**

The data obtained was transposed onto a Microsoft Excel document and thereafter cleaned. Basic descriptive statistics of the demographic information, DHQ and DPPQ were analysed on Excel and presented in graphical and table form. Descriptive statistics and inferential statistics were also analysed using TIBCO Statistica™ 10.0.

With respect to inferential statistics, the following statistical analyses were used to determine patterns, trends and significance: T-tests for independent samples, within-group correlations for independent samples, One-Way Analysis of Variance (ANOVA), linear regression and Multivariate Analysis of Variance (MANOVA).

# CHAPTER 4: RESULTS

Presented in this chapter are the findings from the data collected from the participants, and have been presented in two sections, namely Descriptive Statistics and Inferential Statistics. Both sections will include an analysis of the three questionnaires participants were required to complete. Namely, Participant Information and Demographics, Driver Habits Questionnaire (DHQ) and Driver Perceptions and Practices Questionnaire (DPPQ). The independent variables were age, sex and race. Each one of these variables was studied in isolation as well as in relation to the other

## 4.1 Descriptive Statistics

### 4.1.1 Demographic Information

A total of 205 participants took part in the study. Of those 205, males accounted for 52% of the sample size (n=107) and females 48% (n=98) (Figure 6). Concerning age group, the largest proportion of age groups was the group aged 55-59 years with a percentage of 44% (n=87), 60-65 at 33% (n=69), 66-70 at 20% (n=42) and 71-79 at 3% (n=7). In terms of race, African accounted for the largest proportion of participants at 71% (n=145), followed by White at 21% (n=43), Coloured at 4% (n=9), and Indians accounted for the least proportion at 3% (n=7).

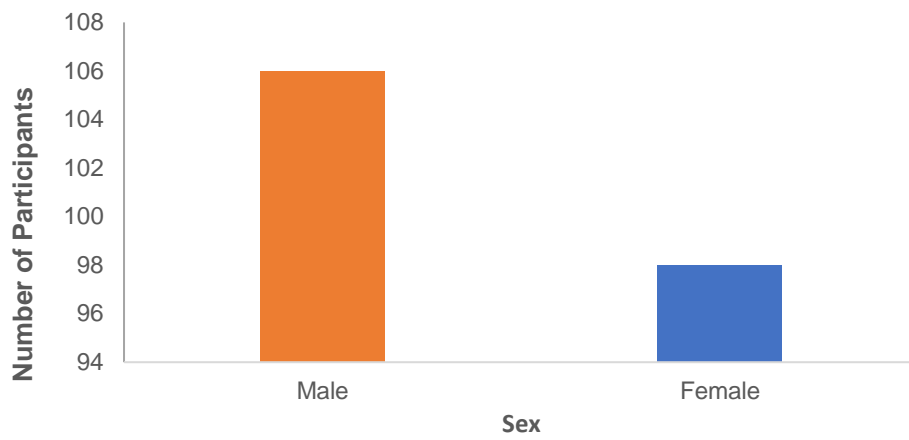


Figure 3: Descriptive Statistics by Sex. (N=205)

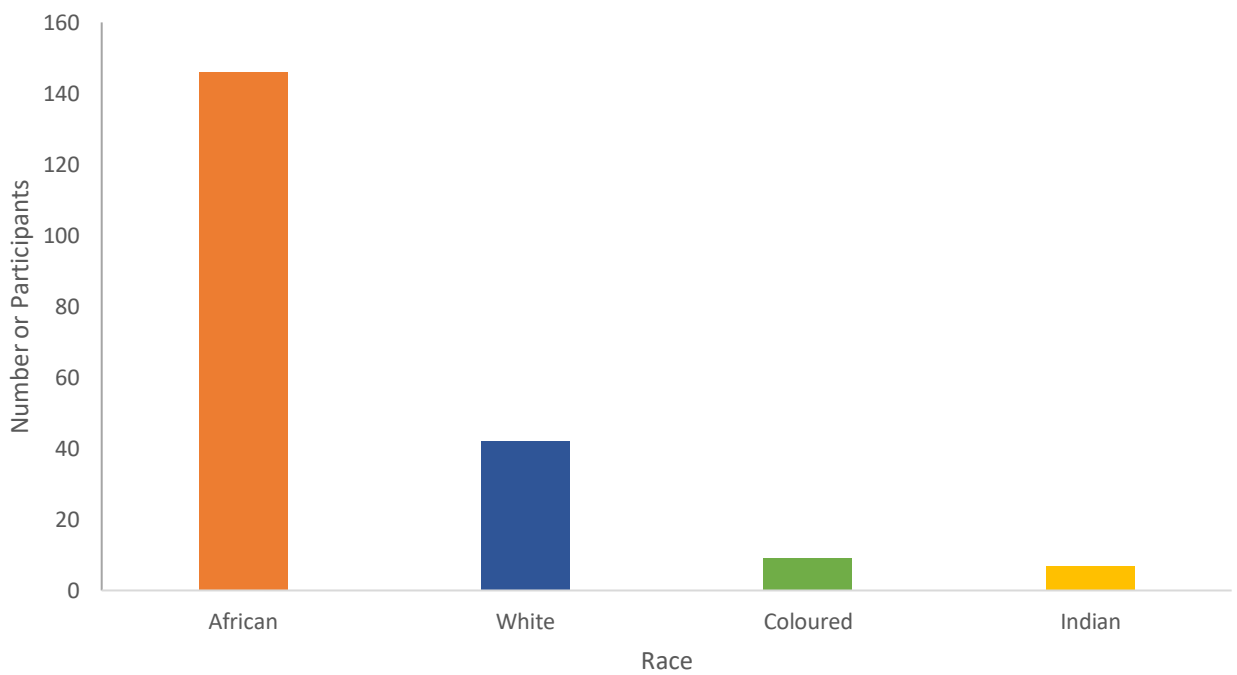


Figure 4: Number of Participants According to Race. (N=205)

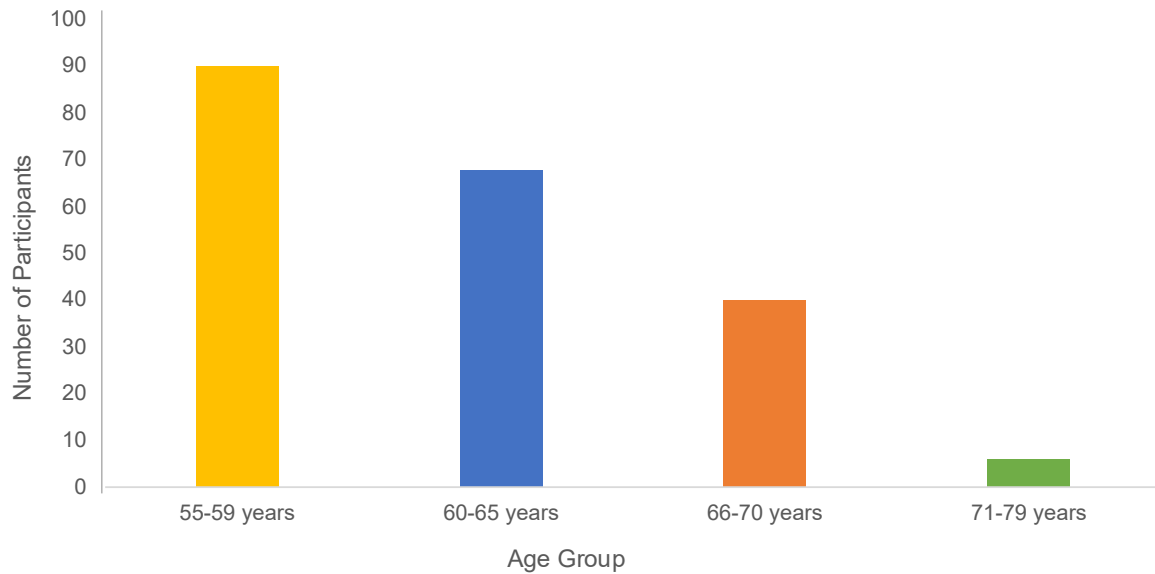


Figure 5: Number of Participants According to Age Group (N=205)

The age group of 55-59 years accounted for 44% of the participant population (N=205), where the participants could have been aged 55 years and above (min = 55 yrs and max <80 yrs). As already mentioned, males accounted for 52% of the participant population (N=107). Table 3, provides a breakdown of the age group by sex. The 55-59 year old age group accounted for the majority of female participants (N=47). Similarly, participants aged between 55-59 years old also accounted for the greatest proportion where males are concerned (N=37).

Table 3: Count of Age Group by Sex (N=205)

| Age Group   | Sex    |      |
|-------------|--------|------|
|             | Female | Male |
| 55-59 years | 47     | 40   |
| 60-65 years | 31     | 38   |
| 66-70 years | 17     | 25   |
| 71-79 years | 3      | 4    |
| Total       | 98     | 107  |
| Grand Total | 205    |      |

In conjunction with the demographic information, participants were presented with questions about their opinions on their general health, driving abilities, and their opinions about their peers' driving capabilities. The responses have been summarised in Figure 9.

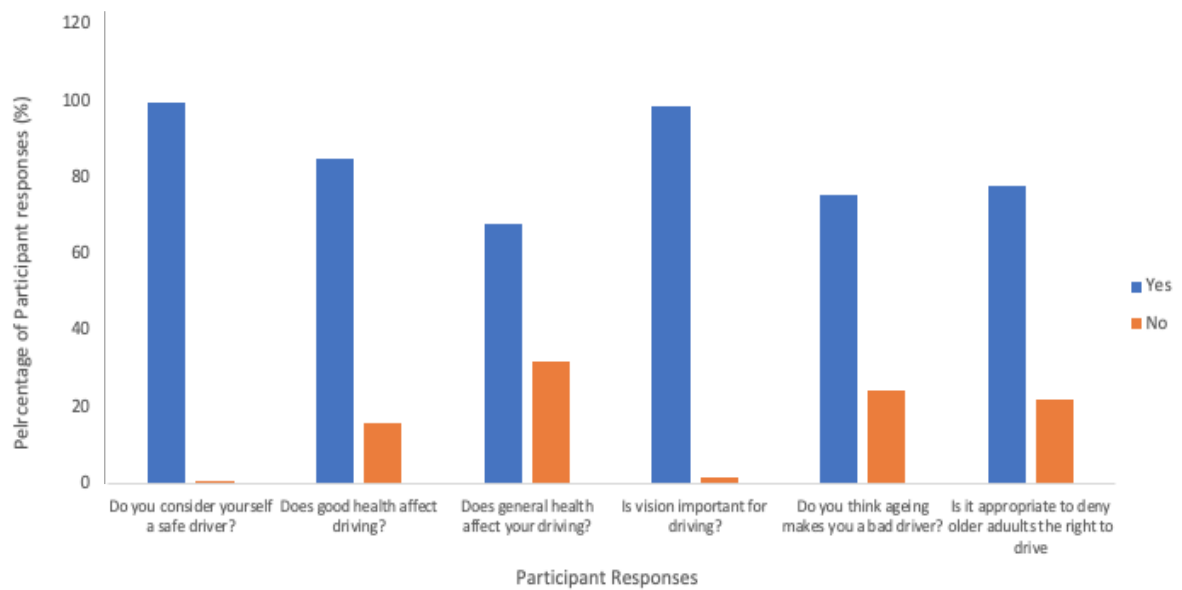


Figure 6: Self-reported responses with respect to confidence in driving and opinions of visual and overall Health (N=205)

Participants were asked to rate their overall health, vision, and driving ability on a scale from 1 to 5, with 1 indicating poor and 5 indicating excellent. The mode and median ratings for each category are summarised in Table 4:

Table 4: Summary of Self-Reported Overall Health, Vision and Driving Ability (1=Excellent, 2=Good, 3=Average and 4 = Poor)

| <b>Aspect</b>   | <b>Mode</b> | <b>Median</b> |
|-----------------|-------------|---------------|
| Overall Health  | 2           | 2             |
| Vision          | 2           | 2             |
| Driving Ability | 2           | 2             |

The mode and median ratings for overall health were both 2, indicating that a significant proportion of participants rated their overall health as 2 (“good”) on the 1 to 5 scale. Similar to overall health, the mode and median ratings for vision were both 2, suggesting that a substantial portion of participants rated their vision as 2. The mode and median ratings for driving ability were also 2, indicating that a notable proportion of participants rated their driving ability as 2.

The prevalence of a rating of “good” across all three aspects or self-reported measures, suggests a common trend in the participants' self-assessments”, whereby participants agree that health affects driving, and that vision is important for driving. With respect to bring “safe” drivers, 193 participants considered themselves to be “safe” drivers, while only 1 responded “no”.

68% of the participants reported that general health affected driving, while 85% (N= of the participants reported that “good” health affected their driving. The 17% difference or discrepancy in responses is believed to be due to semantic reasons. The questions asked did not specify health conditions, and thus, responses were based on how individuals interpreted the questions.

#### 4.1.2 Driver Habits Questionnaire

Of the total number of participants (N=205), 199 participants reported themselves as active drivers, while 5 reported themselves as inactive drivers. In interpreting this, one needs to consider that during the data collection period, South Africa was placed under movement restrictions due to COVID-19. To be considered an “active” driver, participants had to have driven within the last three months from when they filled out the questionnaires.

##### a) *Current driving*

Some participants mentioned that although they had been inactive, an unprecedented event- the COVID-19 pandemic forced them to start driving again. With respect to the inactive drivers, four of the participants’ reasons for not driving were health-related, while one was an alternative self-regulatory reason. This is illustrated in Figure 10. The other inactive participants did not have a motor vehicle at their disposal (at the time they filled out the questionnaire).

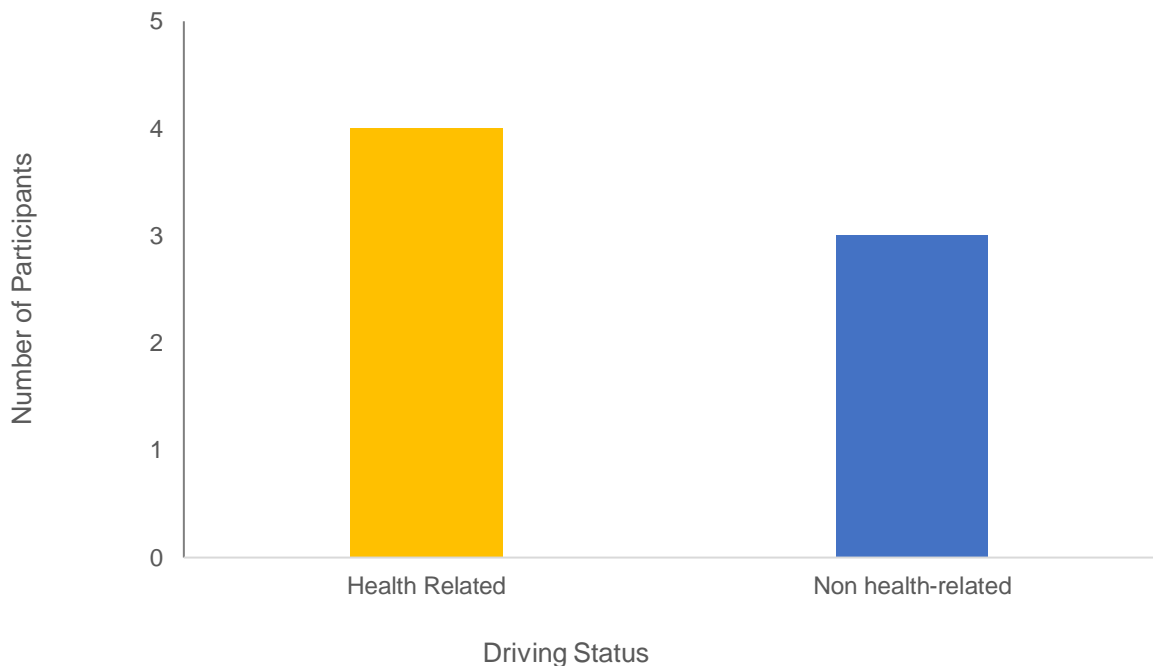


Figure 7: Illustration of Inactive Drivers (N=5)

Participants who attributed their driving cessation to being health-related reported: a decline in visual capabilities, chronic illness (e.g. diabetes) and/or injury as the reasons behind the cessation. With respect to the non-health related former drivers, the reasons were attributed to an inaccessibility to a motor vehicle.

Only participants who were reported as active drivers were required to fill out the DHQ beyond question number 4. As touched upon in the review of literature, vision plays an important role in the task of driving, such that the issuing or renewal of a driver's license requires that an eye examination be performed. When asked about using glasses or contact lenses, participants could respond as follows: 1= yes, 0 = no. 148 participants responded "no", while 56 reported that they indeed did make use of glasses or contact lenses.

Illustrated in Figure 8, are pie charts displaying the proportion of active drivers who reported on seatbelt use, and how they preferred to get around.

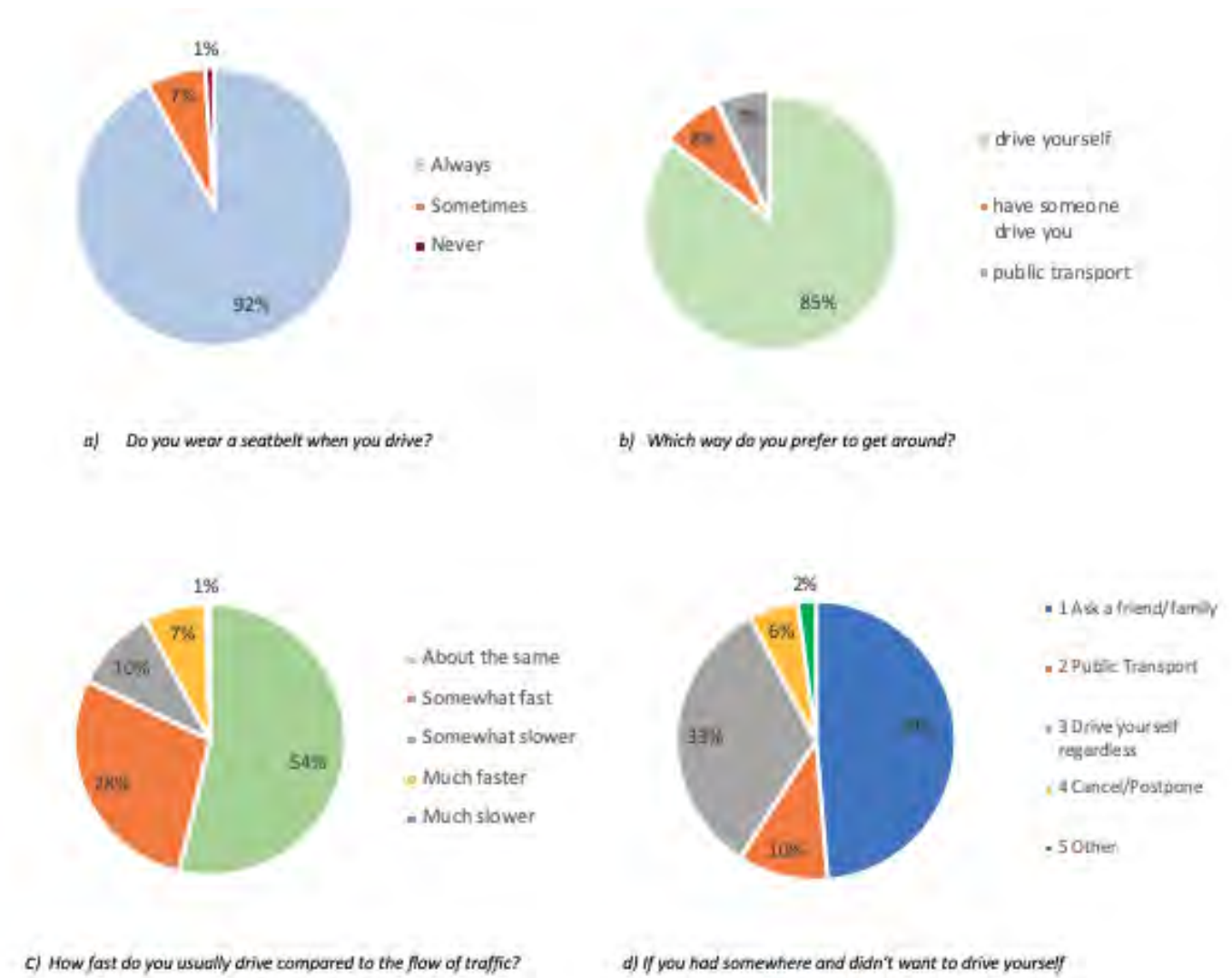


Figure 8: Current driving practices of active drivers (N=205)

92% of the active drivers indicated that they “always” made use of seatbelts, while 7% admitted to not always making use of them. Although only 1% reported “never” making use of a seatbelt (Figure 8a), it still raises concerns, given that research has shown that older adults are more susceptible to serious injury in accidents (Allen et al., 2019b; Brelet et al., 2016b; Mitchell, 2008). 15% of the active drivers preferred being driven, with 7% preferring public transportation and 8% other means that are not classified as

official modes of public transportation; however, the response for those who preferred to drive themselves was 85% (Figure 8b). With respect to the flow of traffic, 1% of the population reported driving much faster compared to the flow of traffic. 54% of the population reported driving at about the same flow of traffic (Figure 8c). This alludes to the fact that the average ageing/elderly Gauteng driver is cognisant of the role that speed plays in driving safety or decision-making.

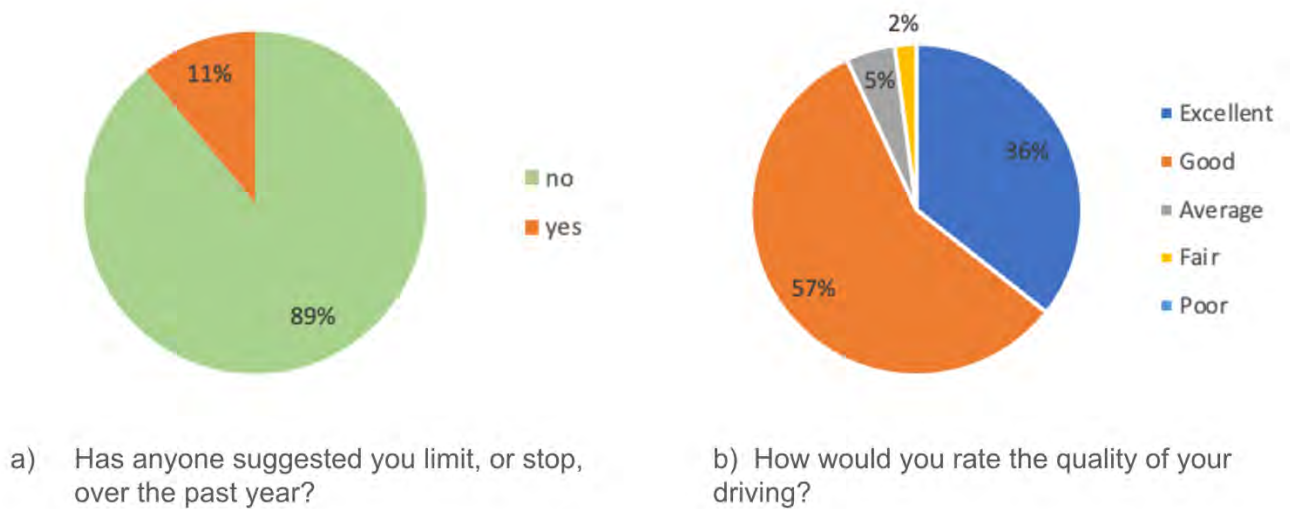


Figure 9: Current Driving Suggestions and Self-rated driving ability (n=195)

Stalvey & Owsley (2000) show that loved ones are more likely to advise an ageing or elderly driver to either limit or cease driving at one point. This could be out of concern, but it can do some harm. Only 11% of the participant samples reported that someone had suggested that they limit or stop their driving (Figure 9a).

Quality of driving is determined by factors that include but are not limited to adherence to regulations, safety measures applied and crash avoidance. Participants were asked to describe the quality of their driving as either excellent, good, average, fair or poor. From greatest to least participant, the ratings were as follows 57% good, 36% excellent, 5% average and 2% fair.

b) Exposure and avoidance

Participants reported driving an average of 5.58 days per week (SD = 1.52), with a minimum of 0 days and a maximum of 7 days. This suggests that, on average, participants in the study engaged in driving activities for a significant portion of the week. The standard deviation of 1.52 indicates moderate variability in the reported number of days participants typically drive in a week, with some individuals driving more frequently than others. With participants driving, on average, approximately 6. This is believed to be a result of the differences in employment status and lifestyle demands. A typical work week in South Africa is 5 days. Within the different age groups of our population, it was expected that, based on employment status and lifestyle demands, there would be differences in the amount of time spent on the road.

Variance and coefficient of variation (CF) were calculated to be 2,61 and 0,29 (29%), respectively. The value obtained for variance confirms what was implied by the standard deviation. This is further confirmed by the low CF value. imply that a great number of the participant population lead lifestyles that require them to drive frequently.

Participants were further asked about challenging scenarios that they may have encountered within 3 months prior to completing the questionnaire. The results thereof are tabulated below.

Table 5: Driving scenarios likely to be experienced

| <u>Driving Scenario</u>                 | <u>Responses (% Total)</u> |    |
|---|----------------------------|----|
| During the past three months, have you: | Yes                        | No |
| a) Driven when it was raining           | 94                         | 6  |
| b) Driven alone                         | 97                         | 3  |
| c) Parallel parked                      | 84                         | 16 |
| d) Driven on highways                   | 91                         | 9  |
| e) Driven on high traffic roads         | 81                         | 19 |

|                                |    |    |
|--------------------------------|----|----|
| f) Driven in rush-hour traffic | 73 | 37 |
| g) Driven at night             | 88 | 12 |

Driving when it's raining: Participants reported driving in rainy conditions with a mean frequency of 0.892 (SD = 0.311), indicating that, on average, participants drove during rainy weather in approximately 89.2% of the time over the past 3 months. The relatively high standard deviation of 0.311 indicates great variability in the frequency of driving in rainy conditions among participants. Essentially, participants may drive frequently in rainy weather, while others may completely avoid it.

Driving alone: Participants reported driving alone with a mean frequency of 0.946 (SD = 0.226), suggesting that, on average, participants drove alone for the majority of their trips over the past 3 months. The standard deviation of 0.226 suggests relatively low variability in driving alone among participants. Most participants reported driving alone consistently across the past 3 months. The reasons behind this may vary based on the demands in lifestyle and the types of regions they commute in.

Parallel parking: Participants reported parallel parking with a mean frequency of 0.971 (SD = 0.169), indicating that, on average, participants frequently engaged in parallel parking manoeuvres over the past 3 months. The low standard deviation of 0.169 indicates minimal variability in the frequency of parallel parking among participants. Most participants reported parallel parking frequently, suggesting that they were unlikely to avoid having to parallel park. This could be an indication of the parking availability at their destinations.

Driving on highways: Participants reported driving on highways with a mean frequency of 0.843 (SD = 0.365), suggesting that, on average, participants drove on highways for a substantial portion of their trips over the past 3 months. The high standard deviation of 0.365 suggests variability in the frequency of driving on highways among participants. Some participants may drive on highways frequently, while others may avoid them at all costs.

Driving on high traffic roads: Participants reported driving on high traffic roads with a mean frequency of 0.912 (SD = 0.284), indicating that, on average, participants encountered high traffic conditions for a significant proportion of their trips over the past 3 months. The moderate standard deviation of 0.284 indicates variability in the frequency of driving on high-traffic roads among participants. Some participants may encounter high traffic frequently, while others may experience it less often. It can be posited that this is largely dependent on when the roads are heavily trafficked and if alternatives are available.

Driving in rush-hour traffic: Participants reported driving in rush-hour traffic. This is probably has to do with traffic, with a mean frequency of 0.828 (SD = 0.378), suggesting that, on average, participants experienced rush-hour traffic conditions for a notable portion of their trips over the past 3 months. The relatively high standard deviation of 0.378 suggests variability in the frequency of driving in rush-hour traffic among participants. Some participants may encounter rush-hour traffic frequently, while others may experience it less often.

Driving at night: Participants reported driving at night with a mean frequency of 0.750 (SD = 0.434), indicating that, on average, participants drove during nighttime hours for a considerable portion of their trips over the past 3 months. The high standard deviation of 0.434 indicates variability in the frequency of driving at night among participants. Some participants may drive frequently at night, while others may avoid it completely.

Table 6: A Depiction of Driving Avoidance Scenarios measured within the Southern African population as a percentage of the sample population. (N=205)

|                                   | <b><u>Level of Difficulty</u></b>   |                     |                     |                    |
|-----------------------------------|-------------------------------------|---------------------|---------------------|--------------------|
|                                   | <b><u>(Sample population %)</u></b> |                     |                     |                    |
| <b>Would you say that you:</b>    | No difficulty at all                | A little difficulty | Moderate difficulty | Extreme difficulty |
| a) Drive when it is raining with: | 37                                  | 46                  | 17                  | 0                  |

|                                      |    |    |    |   |
|--------------------------------------|----|----|----|---|
| b) Drive alone with:                 | 89 | 10 | 1  | 0 |
| c) Parallel parking with:            | 67 | 23 | 10 | 0 |
| d) Drive on highways with:           | 79 | 19 | 2  | 0 |
| e) Drive on high-traffic roads with: | 63 | 33 | 4  | 0 |
| f) Drive in rush-hour traffic with:  | 60 | 30 | 8  | 2 |
| g) Drive at night with:              | 53 | 28 | 18 | 1 |

A large proportion of participants drove in scenarios considered to be “difficult”. Those who had avoided any of the seven “challenging” situations in Table 5, were asked if their avoidance was due to visual challenges or not (Table 6). Only 3 of those participants attributed the avoidance to visual problems. Other reasons were non-vision related; however, specifics were not asked.

In Table 6 those who had driven in the challenging scenarios could give a rating of how challenging the situation was for them. As can be seen above, most participants drove alone with no difficulty at all; similarly, participants did not find much difficulty in handling the other scenarios. However, rainy weather, night-time driving and parallel parking are the scenarios that most seemed to battle with.

Driving when it is raining: Mean: 4.176, Standard Deviation: 0.669

On average, participants reported feeling that they experienced "a little difficulty" (Mean = 4.176) when driving in rainy conditions. The standard deviation of 0.669 suggests variability in participants' perceptions, with some feeling more comfortable (reporting lower difficulty) than others.

Driving alone: Mean: 4.878 Standard Deviation: 0.435

Participants, on average, reported feeling that they experienced "no difficulty at all" (Mean = 4.878) when driving alone. The low standard deviation (0.435) indicates that most participants felt very comfortable driving alone, with minimal variability in responses.

Parallel parking: Mean: 4.645 Standard Deviation: 0.681

Interpretation: On average, participants reported feeling that they experienced "a little difficulty" (Mean = 4.645) with parallel parking. The standard deviation of 0.681 suggests variability in participants' perceptions, with some feeling more comfortable (reporting lower difficulty) than others.

Driving on highways: Mean: 4.762 Standard Deviation: 0.597

On average, participants reported feeling that they experienced "a little difficulty" (Mean = 4.762) when driving on highways. The moderate standard deviation (0.597) indicates variability in participants' perceptions, with some feeling more comfortable (reporting lower difficulty) than others.

Driving on high traffic roads: Mean: 4.698 Standard Deviation: 0.521

On average, participants reported feeling that they experienced "a little difficulty" (Mean = 4.698) when driving on high traffic roads. The moderate standard deviation (0.521) suggests variability in participants' perceptions, with some feeling more comfortable (reporting lower difficulty) than others.

Driving in rush-hour traffic: Mean: 4.435 Standard Deviation: 0.666

On average, participants reported feeling that they experienced "a little difficulty" (Mean = 4.435) when driving in rush-hour traffic. The relatively high standard deviation (0.666) indicates variability in participants' perceptions, with some feeling more comfortable (reporting lower difficulty) than others.

Driving at night: Mean: 4.198 Standard Deviation: 0.824

On average, participants reported feeling that they experienced "a little difficulty" (Mean = 4.198) when driving at night. The high standard deviation (0.824) suggests variability in participants' perceptions, with some feeling more comfortable (reporting lower difficulty) than others.

These interpretations provide insight into participants' perceptions of the difficulty they experience in various driving scenarios. The variability in responses highlights differences in individual comfort levels and experiences.

#### 4.2.1 Crashes and citations

13 (7%) of the active drivers (N=192) reported having been in an accident where they were the driver. Cumulatively, these 13 drivers were responsible for a total of 17 accidents. Police officers were called to the scene of 7 (41%) of the accidents, where (N=17). With respect to being pulled over by law enforcement, irrespective of whether a ticket was issued or not, 62 participants reported being stopped by law enforcement officers. Of the 62 participants stopped by law enforcement, 35 reported that they were issued traffic tickets.

#### 4.2.2 Driving Space

With respect to driving, space drivers were asked about where they had driven in the past year. It was anticipated that all active drivers (N=192) would report driving in their immediate neighbourhood; however, only 169 (88% of active drivers) reported driving in their immediate neighbourhood. More expected, 172 (90% of the active driver population) people reported driving beyond their immediate neighbourhood. 179 participants reported driving to more distant towns or cities, while 148 travelled beyond the borders of the Gauteng province.

### 4.3 DPPQ: Drivers Perception and Practices Questionnaire

#### 4.3.1 Impact of vision and concern for health

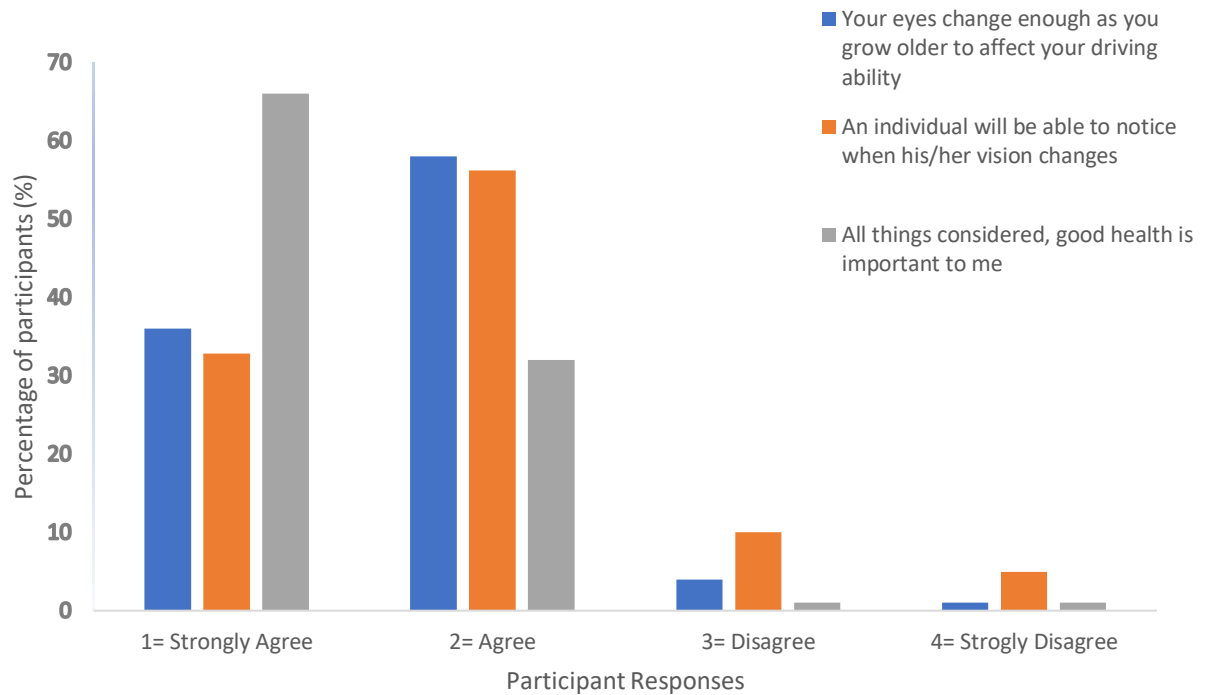


Figure 10: The Impact of vision on driving and concerns for health and safety. (N=205)

This section of the questionnaire focused on how participants felt about basic questions about overall health (visual and overall health). Depicted in Figure 10 above are the questions asked. A Likert scale was used to express whether participants agreed or disagreed with the question and to what degree.

Health and vision are factors that need to be considered when driving. Participants were asked to rate a) whether or not ageing came with no noticeable changes in vision and health. When participants were asked

*“Your eyes change enough as you grow older to affect your ability to drive”* 35% of the population strongly agree, while a greater 58% agree. Conversely, 4% disagreed, while 1% strongly disagreed. When asked, *“An individual will be able to notice when*

his or her vision changes?" 33% strongly agreed, while 56% agreed. 10% disagreed, while 9% strongly disagreed.

#### 4.3.2 Attitudes towards driving

This section of the questionnaire (items 4- 10), pertained to attitudes towards driving and was completed using a Likert scale from 1-4, where 1 is strongly agree and 4 is strongly disagree. This is depicted in Figure 13. In conjunction with the Figure, a table is presented below to highlight the more frequent results.

Table 6 DPPQ Attitudes (N=201)

| Questions  | Number of Responses (% Total) |       |          |                   |
|--|-------------------------------|-------|----------|-------------------|
|  | Strongly Agree                | Agree | Disagree | Strongly Disagree |
| 4. The drivers of automobiles are best qualified to judge their own physical fitness to drive cars       | 18%                           | 44%   | 28%      | 10%               |
| 5. No person should be denied the right to drive   | 20%                           | 28%   | 44%      | 8%                |
| 6. Every motorist should be required to pass a driving skill test once in five years to continue driving | 28%                           | 36%   | 25%      | 11%               |

|   |     |     |     |     |
|---|-----|-----|-----|-----|
| 7. Drivers who take chances eventually become expert drivers  | 4%  | 6%  | 33% | 56% |
| 8. Persons with many years of driving experience should not be required to submit to examine in later years | 10% | 16% | 39% | 35% |
| 9. Because "Things happen", one should not be concerned with the prevention of accidents                    | 3%  | 3%  | 35% | 59% |
| 10. The occurrence of accidents is a matter of chance and should be regarded as unavoidable                 | 8%  | 26% | 36% | 30% |
| 11. Possession of a driver's license is evidence of the driving ability of the individual                   | 13% | 31% | 34% | 22% |
| 12. The sturdy construction of automobiles  | 10% | 29% | 38% | 23% |

|  |     |     |     |     |
|--|-----|-----|-----|-----|
| assures my safety at any speed.  |     |     |     |     |
| 13.It doesn't matter when or where you drive, your chances of having an accident are still the same      | 18% | 38% | 32% | 12% |
| 14.I should not have to plan when and where they drive   | 8%  | 35% | 32% | 26% |
| 15.Changing the way, I drive would take too much thought. I don't want to have to think about my driving | 7%  | 17% | 54% | 29% |
| 16.I should just be able to get in the car and go somewhere whenever I feel like it.                     | 18% | 32% | 35% | 15% |

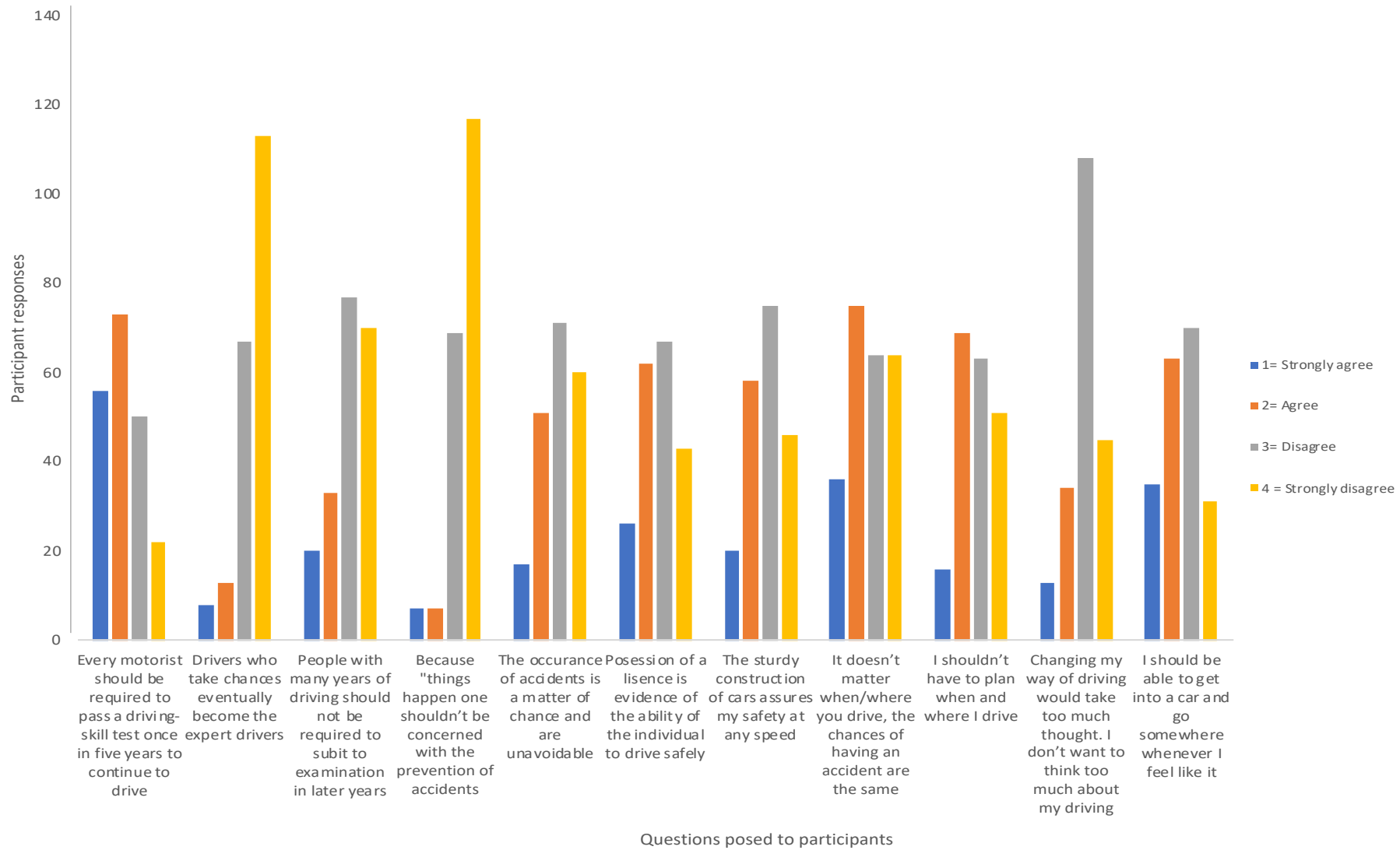


Figure 11: Participants' Attitudes toward Driving

This section of the questionnaire focused on how participants felt about basic questions about overall health (visual and otherwise). As depicted in Figure 11, the questions are asked.

Driving is a complex task, as mentioned. Health and vision are factors that need to be considered when driving. Participants were asked to rate a) whether or not ageing came with no noticeable changes in vision and health. When participants were asked

*"Your eyes change enough as you grow older to affect your ability to drive"*, The following descriptive statistics were noted:

Perception of Vision Impact: Participants reported a mean of 2 or "Agree" ( $1.709 \pm 0.621$ ) on the item "Your eyes can change enough to affect driving ability". This suggests that, on average, participants had the perception that their eyes could, in fact, change enough to impact their driving ability. The standard deviation of 0.621 indicates some variability in participants' responses, with some expressing higher levels of concern about this issue. Meaning that while the average perception is that most people would be able to notice changes in their vision, others may not agree with this. In other words, they don't think that they may become easily aware of the changes in their own vision.

Some participants may have expressed stronger concerns about their vision changing and affecting their driving ability, while others seem to be less concerned.

For the item "An individual will be able to notice visual changes", participants reported a slightly higher mean score of ( $1.792 \pm 0.666$ ). This still translates to the fact that, on average, participants "agree" that individuals would be able to notice visual changes. The standard deviation of 0.666 suggests variability in participants' perceptions, with some expressing stronger beliefs in this statement than others.

Concerns for Health: Participants reported a mean of ( $1.381 \pm 0.589$ ) on the item "All things considered, good health is important to me". This indicates that, on average, participants strongly agreed that good health is important to them. The standard deviation of 0.589 suggests some variability in the importance participants placed on good health, with some expressing stronger agreement than others. This means that

while the average agreement or consensus is strong, there are differences among participants in the extent to which they prioritise good health. Some participants may place very high importance on good health, while others may have slightly lower levels of agreement.

In a nutshell, the variability in participants' responses indicates that individuals have different perceptions and attitudes towards vision impact, noticing visual changes, and the importance of good health. This diversity in perspectives and concerns among participants should be considered when addressing vision-related issues and promoting health in the context of driving safety. Similarly, it should be taken into consideration that issues of socioeconomic and lifestyle factors should be explored.

### **Attitudes towards driving**

This section of the questionnaire (items 4-10), pertained to attitudes towards driving and safety practices and was completed using the same Likert scale previously, where 1 is strongly agree and 4 is strongly disagree.

Participants reported a mean score of 2 or “agree” ( $2.292 \pm 0.880$ ) on the item “The drivers of cars are best qualified to judge their own physical fitness to drive”. This suggests that, on average, participants disagreed somewhat with the notion that individuals are best qualified to assess their own fitness to drive. The standard deviation of 0.880 indicates variability in participants' opinions, with some expressing stronger disagreement than others. However, the mode of 2, is a clear indication that the responses seen in this particular study are in agreement that drivers are good judges of their own fitness to drive. This of course, does not come without scrutiny, as one would have to look at road accident and licensing statistics to determine whether or not this is a true representation of reality.

### **Attitudes Towards Driving Rights and Regulation:**

Participants reported a mean score of 2 or “agree” ( $2.408 \pm 0.902$ ) on the item “No one should be denied the right to drive”. This indicates that, on average, participants agreed with the notion that everyone should have the right to drive. The standard

deviation of 0.902 suggests variability in participants' opinions, with some expressing stronger agreement than others.

Participants reported a mean of 3 ( $3.418 \pm 0.784$ ) on the item "Drivers who take chances eventually become the expert drivers". This indicates that, on average, participants disagree with the notion that taking chances while driving leads to becoming an expert driver. While the standard deviation of 0.784 suggests variability in participants' opinions, with some expressing stronger agreement than others, the mode reported, once again, reflects the perceptions of the participants of the particular study. However, this may not be quite the case with reality, as published statistical data would have to verify this fact.

Participants reported a mean score of 3 ( $3.480 \pm 0.730$ ) on the item "Because 'things happen one shouldn't be concerned with the prevention of accidents'". This suggests that, on average, participants disagreed with the notion that accidents are unavoidable and not worth being concerned about. The standard deviation of 0.730 indicates variability in participants' opinions, with some expressing stronger agreement than others.

Participants reported a mean score of 3 or "disagree" ( $2.925 \pm 0.808$ ) on the item "Changing my way of driving would take too much thought. I don't want to think too much about my driving". This indicates that, on average, participants disagreed with the idea of changing their driving behaviour or thinking too much about their driving. This gives a positive indication in terms of how aware drivers are about their perceptions of being road users. The standard deviation of 0.808 suggests variability in participants' opinions, with some expressing stronger disagreement than others.

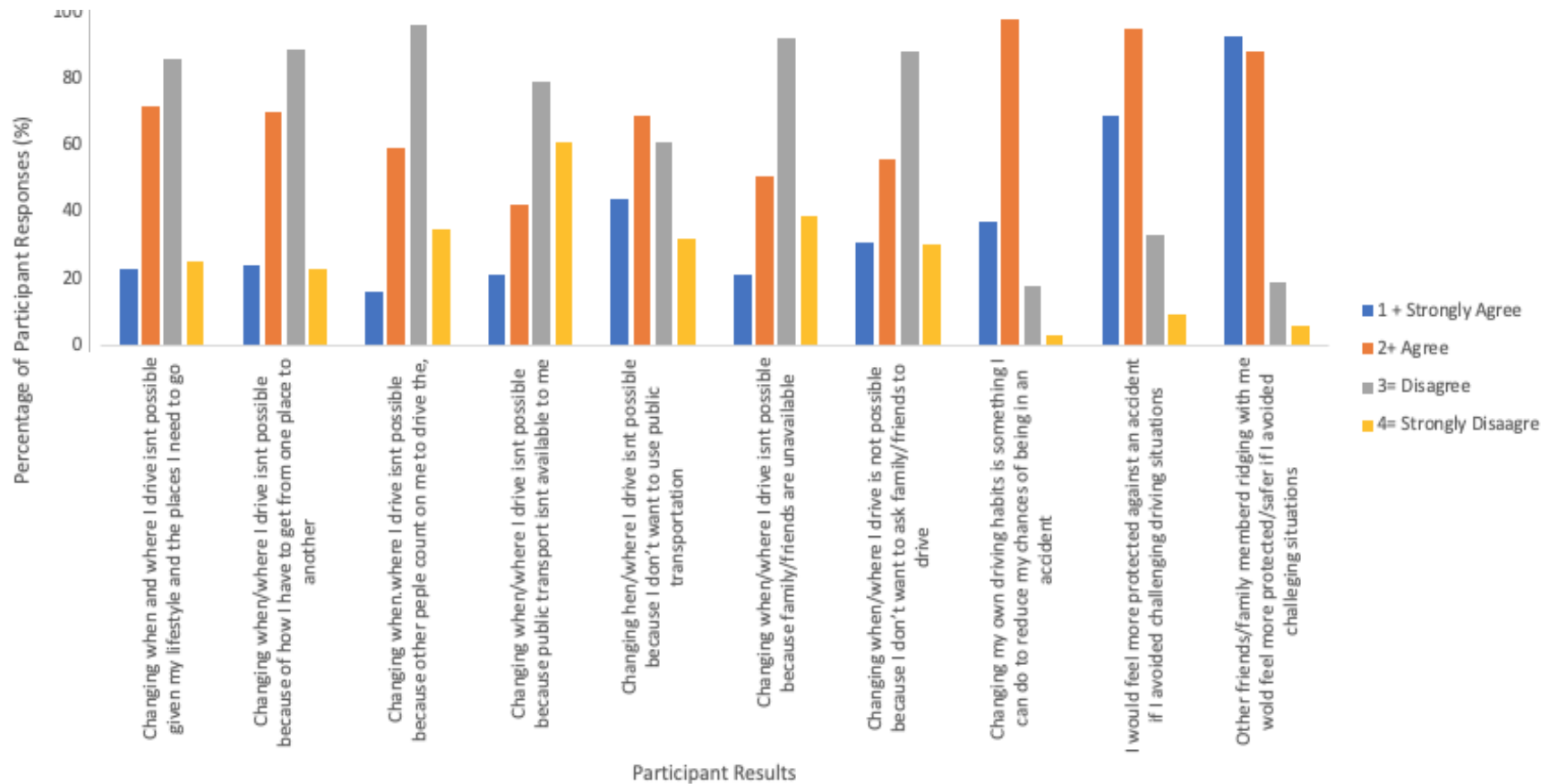


Figure 12: A Summarised Illustration of Perceived Barriers

## Perceived barriers

When it came to perceived barriers, participants were asked questions regarding the changes they were willing or unwilling to make with respect to their driving. A graphical illustration of these question is presented in Figure 15

Changing When and Where I Drive Isn't Possible Given My Lifestyle and Places I Need to Go: Participants, on average, reported a mean of 3 or "disagree" ( $2.552 \pm 0.851$ ) with this statement. This suggests that they perceive their lifestyle and the places they need to go as significant barriers to changing their driving habits. This could be due to a host of factors such as lifestyle demands, socio-economic factors and societal opinions. The relatively high standard deviation (Std. Dev = 0.851) indicates variability in participants' responses, with some feeling more strongly than others that their lifestyle constraints limit their ability to change their driving habits.

Changing When/Where I Drive Isn't Possible Because of How I Have to Get from One Place to Another: Similar to the previous item, a mean value of 3 or "disagree" was expressed. ( $2.537 \pm 0.846$ ) with this statement. They perceive the logistics of transportation between places as a barrier to changing their driving habits. This brings about complex issues of the number of cars present on South African roads, availability and reliability of public transportation and lifestyle demand that directly influence the types of transportation that would be most beneficial.

Changing When/Where I Drive Isn't Possible Because Other People Count on Me to Drive: Participants, on average, disagreed ( $2.714 \pm 0.831$ ) with this statement. They feel that their role as a driver for others presents a barrier to changing their driving habits. Based on different lifestyle demands, there may be a plethora of factors that inform driving practices. While some may be easily modified, others may not. For instance, with the COVID-19 pandemic, there were respondents who mentioned that, while they limited their driving, or perhaps even ceased altogether, pandemic-related restrictions required them to make alterations to their practices, necessitating the need for them to once again drive themselves. The standard deviation (0.831) indicates variability in participants' feelings of obligation to drive for others.

Changing When/Where I Drive Isn't Possible Because Public Transport Isn't Available to Me: Participants, on average, disagreed with this statement ( $2.867 \pm 0.985$ ). They perceived the lack of public transportation options as a considerable barrier or maybe even a challenge to changing their driving habits. The standard deviation (0.958) suggests that access to and reliance on public transportation may be a considerable challenge, such that some would still drive themselves regardless of how they feel. This was touched on in Figure 11.

Changing When/Where I Drive Isn't Possible Because I Don't Want to Use Public Transportation: Building on the previous item, this item delves into whether or not participants are actually interested in making use of public transportation. With a mode of 4, it would seem that most participants did, in fact, not want to use public transportation. On average, however, a moderate level of agreement ( $2.389 \pm 0.991$ ) with this statement was reported. These participants perceive their personal preference against using public transportation as a barrier to changing their driving habits. The difference between the responses "agree" and "disagree" was only 6, as 67 participants agreed with the question, while 61 disagreed. At face value, this gives the impression of little variability; however, the standard deviation (0.991) would lead one to believe otherwise. Inferential statistics are required to determine the veracity of the responses given.

Changing When/Where I Drive Isn't Possible Because Family/Friends Are Unavailable: On average, participants expressed a relatively high level of disagreement (Mean =  $2.750 \pm 0.878$ ) that they feel that the availability of family or friends presents a barrier to changing their driving habits. In fact, the reported mode was "disagree" with 44% of the respondents giving this response (N=91). The standard deviation (0.878) suggests high variability in participants' reliance on family or friends for transportation.

Changing When/Where I Drive Is Not Possible Because I Don't Want to Ask Family/Friends to Drive: Participants, on average, reported a moderate level of agreement ( $2.574 \pm 0.923$ ) with this statement. They perceive their reluctance to ask family or friends for transportation as a barrier to changing their driving habits. The reported mode for this item was 3 or "disagree" (42% of participants), however, with 26% of the participants responding with "agree", this brings about questions of whether

or not there is a significant difference between whether or not participants agree or disagree on the question asked. Inferential statistics were required to verify this.

Changing My Own Driving Habits Is Something I Can Do to Reduce My Chances of Being in an Accident: Participants, on average, expressed a high level of agreement ( $1.700 \pm 0.692$ ) with this statement. They believe that changing their driving habits can reduce their risk of accidents.

I Would Feel More Protected Against an Accident if I Avoided Challenging Driving Situations: Participants, on average, reported a moderate level of agreement ( $1.921 \pm 0.817$ ) with this statement. They feel that avoiding challenging driving situations would enhance their safety against accidents. The standard deviation (Std. Dev = 0.817) indicates variability in participants' beliefs about the effectiveness of avoiding challenging driving situations for accident prevention.

Other Friends/Family Members Riding with Me Would Feel More Protected/Safer if I Avoided Challenging Situations: Participants, on average, expressed a moderate level of agreement (Mean = 1.704) with this statement. They believe that avoiding challenging driving situations would make other passengers feel safer. The standard deviation (Std. Dev = 0.759) suggests variability in participants' perceptions of the impact of their driving behaviour on the safety of others.

The perceived barriers to changing driving habits highlighted in the questionnaire reflect various factors influencing participants' behaviour and decision-making regarding transportation.

Lifestyle constraints, transportation logistics, obligations to others, access to public transportation, personal preferences, and concerns about inconveniencing family or friends are significant barriers perceived by participants.

### **4.3 Inferential Statistics**

In this section of the results, inferential statistics were employed to further analyse the data obtained from the DHQ and the DPPQ. Inferential statistics provide a more objective and nuanced depiction of the results. With the independent variables being sex, age and race, It was particularly important to establish how each variable related

to both the questionnaires, as that would ensure that the aims of this research were attended to. By applying various statistical analysis tools, not only were this research's aims explored, but relationships and patterns that would not have been determined by descriptive statistics alone were identified. While many statistical analyses were conducted, not all results are presented below; however, the outstanding result can be found in Appendix C.

## **Driver Habits Questionnaire (DHQ)**

### *Current Driving*

An Independent t-test was conducted to distinguish whether there were significant differences between the results obtained by male and female participants. A confidence level of 95% was used for this particular statistical test, as well as the rest of the inferential statistics conducted in the study. The questions below represent the various sections of the DHQ and thus the dependent variables

### *Do you drive?*

Similar to the descriptive statistics conducted the mean for females who reported being active drivers driving was 0.959, while for males it was slightly higher at 0.991. However, with a t-value of -1.472 and a p-value of 0.143 ( $p > 0.05$ ), it was confirmed that there was no significant difference in the proportion of males and females who reported driving. Implying that there aren't any clear indications of one sex driving more than the other. This could be for various reasons for example:

- a. Due to the geographical location wherein participants were sourced. Gauteng is known to be a province that not only continues to grow but also forms the country's economic hub.
- b. Lifestyle demands based on socioeconomic status and interests.
- c. Where and how participants were sought, as well as how questionnaires were responded to.

*Do you wear glasses or contact lenses when you drive?*

The mean for females wearing glasses or contact lenses (corrective lenses) when driving was 0.258, compared to 0.290 for males. With a t-value of -0.509 and a p-value of 0.611 ( $p > 0.05$ ), there was no significant difference between males and females in terms of wearing glasses or contact lenses while driving. Suggesting that sex does not play a significant role in the likelihood of wearing corrective lenses, particularly while driving.

*Do you wear a seatbelt when you drive?*

The mean for females wearing a seatbelt when driving was 1.052, while the mean value for males was 1.065. The t-value of -0.386 and the p-value of 0.700 indicate that there was once more no significant difference between males and females in terms of wearing seatbelts while driving. Based on the above-mentioned results, it can be said that both genders exhibit similar behaviours regarding seatbelt usage while driving. Based on the literature conducted (Blanchard et al., 2010; Cordellieri et al., 2016; Rhodes & Pivik, 2011a; Tuokko et al., 2007) It has been noted that men are more likely to make risky driving decisions as opposed to women; these decisions are based on several factors, as already highlighted in the literature review. To reiterate, just two of those a) Males try to test limits with the belief that it gives them more experience and b) Female drivers are not only seen as more cautious but also perceive themselves to be so as opposed to their male counterparts.

Based on the results of the independent t-tests, it is suggested that there are no significant sex differences in driving behaviours such as driving frequency, wearing glasses or contact lenses, and wearing seatbelts. These findings provide valuable insights into the driving habits of both males and females within the studied population, which differ from other studies conducted around the globe.

Table 7: Independent t-test Current Driving

| Questions:  | Mean   | Mean  | t-value | df      | p     | Valid N | Valid N | Std. Dev | Std. Dev | F-ratio | P     |
|---|--------|-------|---------|---------|-------|---------|---------|----------|----------|---------|-------|
|   |        |       |         |         |       |         |         |          |          |         |       |
|   | Female | Male  |         |         |       | Female  | Male    | Female   | Male     |         |       |
| Do you drive?   | 0.959  | 0.991 | -1.472  | 202.000 | 0.143 | 97.000  | 107.000 | 0.200    | 0.097    | 4.274   | 0.000 |
| Do you wear glasses or contact lenses when you drive? | 0.258  | 0.290 | -0.509  | 202.000 | 0.611 | 97.000  | 107.000 | 0.440    | 0.456    | 1.075   | 0.721 |
| Do you wear a seatbelt when you drive?                | 1.052  | 1.065 | -0.386  | 202.000 | 0.700 | 97.000  | 107.000 | 0.222    | 0.284    | 1.631   | 0.015 |

Concerning age groups, Kruskal-Wallis Analysis of Variance (ANOVA) by Ranks was used to make inferences on current driving habits. The results thereof are presented below. The Kruskal-Wallis test was utilised due to the ordinal nature of the data.

*Do You Wear a Seatbelt When You Drive?*

An inferential analysis was conducted to explore the association between differences in age groups and the practice of wearing a seatbelt while driving. The age groups varied between adults aged between 55 and 80+ years. With a p-value of 0.748, it can be said that there was no significant difference ( $p > 0.05$ ) between seatbelt use among the different age groups. Thus, it can be deduced that age alone does not affect the likelihood of wearing a seatbelt while driving. Rather, it is believed that other factors may also greatly affect this habit. Hence, there is a need to explore within-group statistics to obtain a clearer image. These results can be observed in Tables 8 and 9 below.

Table 8: Kruskal-Wallis ANOVA (Age Group)

|  |         |  |            |
|--|---------|--|------------|
|  |         | Kruskal-Wallis ANOVA by Ranks: Do you wear a seatbelt when you drive?<br>Independent (grouping) variable: Age Group<br>Kruskal-Wallis test: $H(3, N=204) = 1.222724$ $p = .7476$ |            |
| Do you wear a seatbelt when you drive? | Valid N | Sum of Ranks   | Mean Ranks |
| 60-65 years                            | 68      | 7002.000   | 102.9706   |
| 55-59 years                            | 87      | 8850.500   | 101.7299   |
| 66-70 years                            | 42      | 4277.000   | 101.8333   |
| 71-79 years                            | 7       | 780.500  | 111.5000   |

Table 9: Kruskal-Wallis ANOVA (Age Group)

|   |   |              |            |
|---|---|--------------|------------|
|   | Kruskal-Wallis ANOVA by Ranks: Do you wear glasses or contact lenses when you drive? Independent (grouping) variable: Age Group Kruskal-Wallis test: $H(3, N=204) = 1.475386$ $p = .6880$ |              |            |
| Do you wear glasses or contact lenses when you drive? |   |              |            |
|   | Valid N   | Sum of Ranks | Mean Ranks |
| 60-65 years   | 68  | 6902.000     | 101.5000   |
| 55-59 years   | 87  | 9235.500     | 106.1552   |
| 66-70 years   | 42  | 4149.000     | 98.7857    |
| 71-79 years   | 7   | 623.500      | 89.0714    |

Following the results in Tables 8 and 9, it was decided that a MANOVA would be used as opposed to a Kruskal-Wallis test, to make overall inferences (between groups) based on age, sex and race, respectively.

Concerning the use of corrective glasses or contact lenses, inferential statistics yielded the same outcome as the previous two of age, having no significant difference in the use of corrective lenses. The results of the Kruskal-Wallis test indicated no significant difference in the practice of wearing glasses or contact lenses while driving across different age groups ( $3, N=204$ ) = 1.475386,  $p = 0.6880$ ).

The  $p$ -value  $> 0.05$ , however, does not support the literature, which indicates that visual function declines with increasing or advancing age, which often results in the need or reliance on corrective lenses. These results were thus not anticipated, as research continues to show the inverse relationship between advancing age and eye health (Ball et al., 1993; Shinar, 1977; Wood, 2002). It was expected that with an increase in age, so will the need for the use of corrective lenses while driving. To expand on these analyses, a MANOVA for overall interactions between current driver habits concerning age, race and sex. The results are tabulated below in Table 10.

Table 10: Multivariate Analysis Test Results (Current Driving)

| Multivariate Tests of Significance |       |          |          |              |             |          |
|------------------------------------|-------|----------|----------|--------------|-------------|----------|
| Sigma-restricted parameterisation  |       |          |          |              |             |          |
| Effective hypothesis decomposition |       |          |          |              |             |          |
| Effect                             | Test  | Value    | F        | Effect<br>df | Error<br>df | p        |
| Intercept                          | Wilks | 1.000000 |          | 0            |             |          |
| Sex                                | Wilks | 1.000000 |          | 0            |             |          |
| Age Group                          | Wilks | 0.908690 | 5.928606 | 3            | 177.0000    | 0.000708 |
| Race                               | Wilks | 1.000000 |          | 0            |             |          |
| Sex*Age<br>Group                   | Wilks | 0.906418 | 6.091362 | 3            | 177.0000    | 0.000574 |
| Sex*Race                           | Wilks | 1.000000 |          | 0            |             |          |
| Age<br>Group*Race                  | Wilks | 0.829180 | 2.864878 | 12           | 468.5895    | 0.000801 |
| Sex*Age<br>Group*Race              | Wilks | 0.822842 | 2.986617 | 12           | 468.5895    | 0.000486 |

Where participants were asked about safety concerns, commuting practices, perception of driving quality and concerns of family, family inferential statistics were also used to probe whether there were significant differences in these variables based on sex, age and race. The results in Table 10 show the following: open skill

Age Group Effect: The multivariate analysis reveals a significant effect of age group on current driving behaviour, as evidenced by a Wilks'  $\lambda$  value of 0.909 and an associated p-value of ( $p = 0.0007$ ), where  $p < 0.05$ . This suggests that age group significantly influences variations in current driving behaviour among the participants; however, this may not correspond with the results obtained from seatbelt usage. Essentially, this analysis suggests that there is a greater need for further analyses to determine the significance of the existing relationship between age, sex and race

(within groups), and current driving. Literature suggests (Chader & Taylor, 2013; Lee & Itoh, 2020; Owsley et al., 2001) that with increasing age, ageing adults should become more aware of the biological age changes that come with increasing age, which ideally should translate into modified driving behaviours. Similarly, the same assertion can theoretically be said concerning sex and age.

When it came to the interaction between sex and age group, sex and race, as well as age group and race, the results obtained from statistical analyses were as follows:

- c) the interaction effect between sex and age group ( $\lambda = 0.906$ ;  $p = 0.000574$ ), was found to be significant ( $p < 0.05$ ). Thus, when observing the relationship between sex and age, there are differences in how males and females of various age groups choose to behave while driving.
- d) Similarly, the interaction effect between age group and race was also found to be significant ( $\lambda = 0.829$ ;  $p = 0.000801$ ). These results indicate that the combined influences of age group and race significantly contribute to variations in current driving behaviours among the study participants. This can be attributed to factors such as employment, domestic responsibilities, personal interests, etc (Dantas et al., 2017; Donorfio et al., 2009). Furthermore, a significant three-way interaction effect between sex, age group, and race on current driving behaviour was also noted. ( $\lambda = 0.823$ ;  $p = 0.000486$ ). With a  $p$ -value  $< 0.05$ , there is a notable significant difference. This complex interplay between sex, age group, and race in shaping driving behaviours highlights the importance of considering these demographic factors collectively when examining driving behaviour outcomes. This is particularly important when looking at Western data versus South African data.

In general, the results of the multivariate tests of significance provide strong evidence of the need to study sex, age and in isolation where driving behaviours, perceptions and practices are observed. Particularly in a country such as South Africa, where social complex factors cannot be ignored. It is in considering these dependent variables that policies and interventions can be better tailored to safety awareness programs, better inform interventions and legislative policies that promote safe driving practices across diverse demographic groups.

## Avoidance

Inferential statistics were run once more to determine the relationship between age, sex and race in typical challenging driving scenarios, which may result in avoidant habits. Essentially, trying to investigate whether the demographics of interest are about driving in challenging situations, do they take them on as inevitable and therefore unavoidable, or do they choose to alter their habits to circumvent these challenges? Table 11 below expounds on this.

Table 11: Multivariate Analysis Test Results (Avoidance)

| Multivariate Tests of Significance |       |          |          |              |             |          |
|------------------------------------|-------|----------|----------|--------------|-------------|----------|
| Sigma-restricted parameterisation  |       |          |          |              |             |          |
| Effective hypothesis decomposition |       |          |          |              |             |          |
| Effect                             | Test  | Value    | F        | Effect<br>df | Error<br>df | p        |
| Intercept                          | Wilks | 1.000000 |          | 0            |             |          |
| Sex                                | Wilks | 1.000000 |          | 0            |             |          |
| Age Group                          | Wilks | 0.953683 | 1.200289 | 7            | 173.0000    | 0.305062 |
| Race                               | Wilks | 1.000000 |          | 0            |             |          |
| Sex*Age<br>Group                   | Wilks | 0.967796 | 0.822371 | 7            | 173.0000    | 0.569920 |
| Sex*Race                           | Wilks | 1.000000 |          | 0            |             |          |
| Age<br>Group*Race                  | Wilks | 0.832588 | 1.163916 | 28           | 625.1826    | 0.257607 |
| Sex*Age<br>Group*Race              | Wilks | 0.856816 | 0.977772 | 28           | 625.1826    | 0.499358 |

Age Group Effect: The multivariate analysis conducted on avoidant habits revealed another significant difference between different age groups on current driving

behaviours based on Wilks's  $\lambda$  ( $\lambda = 0.954$ ) and a non-significant p-value ( $p = 0.305$ ) where ( $p > 0.05$ )

The interaction effects between sex and age group, sex and race, and age group and race, also underwent statistical analysis. The Wilks'  $\lambda$  values for these interaction effects were 0.968, 1.00, and 0.833, respectively. This can be translated into the impacts of age, sex and race (independent variables) on avoidant habits, which are worth noting. Ultimately, this suggests that participants should be highly aware of the challenges that come with driving under those conditions. and may ultimately modify their behaviours. The corresponding p-values were (sex and age group) 0.570, (sex and race) 1.00, and (age group and race) 0.258, respectively, wherein in all three cases  $p > 0.05$ . Indicating significant differences between a) how sex and age affect avoidance b) how race and sex affect avoidance, and c) how age group and race affect avoidant behaviours. Based on sex and age, all groups exhibit the same avoidance behaviour, which can also be said about the groups classified under sex and race, and age group and sex.

Similarly, based on the Wilks  $\lambda$  values, a significant three-way interaction effect between sex, age group, and race on current driving habits was identified. The Wilks'  $\lambda$  value for this interaction was 0.857, while the p-value reported was ( $p = 0.499$ ), where  $p > 0.05$ . Suggesting that the combined influences of sex, age group, and race were not significant, thus showing no difference in how the independent variables interact with situations that prompt avoidance.

#### Driver Perceptions and Practices Questionnaire (DPPQ)

Similar to the DHQ, inferential statistics were conducted on the applicable sections of the DPPQ. Building upon the descriptive statistics, non-parametric statistical analyses were conducted to identify possible relationships between demographic factors such as sex, race and age on driver behaviour within a South African context. Multivariate tests of significance (MANOVA) were conducted to examine the combined effects of age, sex, and race, on driver behaviour as assessed through DPPQ. Tables 12, 13 and 14 below depict the results of the MANOVA.

Table 12: Multivariate Analysis Test Results concerning (Impact of Vision & Concern for Health)

| Multivariate Tests of Significance |       |          |          |              |             |          |
|------------------------------------|-------|----------|----------|--------------|-------------|----------|
| Sigma-restricted parameterisation  |       |          |          |              |             |          |
| Effective hypothesis decomposition |       |          |          |              |             |          |
| Effect                             | Test  | Value    | F        | Effect<br>df | Error<br>df | p        |
| Intercept                          | Wilks | 1.000000 |          | 0            |             |          |
| Sex                                | Wilks | 1.000000 |          | 0            |             |          |
| Age Group                          | Wilks | 0.976392 | 1.410408 | 3            | 175.0000    | 0.241386 |
| Race                               | Wilks | 1.000000 |          | 0            |             |          |
| Sex*Age<br>Group                   | Wilks | 0.997544 | 0.143596 | 3            | 175.0000    | 0.933664 |
| Sex*Race                           | Wilks | 1.000000 |          | 0            |             |          |
| Age<br>Group*Race                  | Wilks | 0.951426 | 0.733494 | 12           | 463.2980    | 0.718807 |

*Impact of Vision and Concern for Health and Safety*

The MANOVA test conducted revealed the following: (Wilks'  $\lambda = 0.976$ ,  $F(3, 175) = 1.410408$ ,  $p = 0.241386$ ). With the Wilks'  $\lambda$  value for age group being 0.976 (closer to 1), it can be said that there is a strong link between age and concern for health and safety concerns. The p-value, on the other hand, shows that while the relationship between age and concern for health may matter, there were no significant differences in how various age groups viewed concerns for health and safety. What this translates to is participants not being oblivious to their visual changes. In essence, participants were aware of how good health affects driving (i.e. seeing the need to alter or modify their driving behaviours

Furthermore, the results obtained in the table above also suggested that the combined influence of sex and age group ( $\lambda = 0.998$ ;  $p = 0.933$ ), sex and race ( $\lambda = 1.00$ ;  $p =$

1.00), as well as age group and race ( $\lambda = 0.951$ ;  $p = 0.719$ ) on driver behaviour was statistically insignificant.

### ***Attitudes Toward Driving***

Table 13: Multivariate Analysis Test Results concerning (Attitudes Toward Driving)

| Effect         | Multivariate Tests of Significance |       |           |          |         |       |
|----------------|------------------------------------|-------|-----------|----------|---------|-------|
|                | Sigma-restricted parameterisation  |       |           |          |         |       |
|                | Effective hypothesis decomposition |       |           |          |         |       |
| Test           | Value                              | F     | Effect df | Error df | p       |       |
| Intercept      | Wilks                              | 1.000 |           | 0.000    |         |       |
| Sex            | Wilks                              | 1.000 |           | 0.000    |         |       |
| Age Group      | Wilks                              | 0.889 | 1.539     | 13.000   | 160.000 | 0.109 |
| Race           | Wilks                              | 1.000 |           | 0.000    |         |       |
| Sex*Age Group  | Wilks                              | 0.973 | 0.337     | 13.000   | 160.000 | 0.985 |
| Sex*Race       | Wilks                              | 1.000 |           | 0.000    |         |       |
| Age Group*Race | Wilks                              | 0.775 | 0.812     | 52.000   | 621.788 | 0.824 |

Based on Table 14 above, the results from the MANOVA suggest that there may be a potential influence of age group on attitudes toward driving ( $\lambda = 0.889$ ). However, with the reported p-value ( $p = 0.109$ ) for the age group effect indicated no significant difference between the effect of age on their attitudes toward driving ( $p > 0.05$ ). It once more necessitates the need for contextualisation of South African-based results in comparison to more advanced Western countries.

The interaction effects of sex and age group, sex and race, as well as age group and race, did not show significant differences in attitudes toward driving. The Wilks'  $\lambda$  value for the interaction between age group and race was 0.775, which, although it confirms that there is some influence (i.e. when coupled, age and race influence the attitudes towards driving), the p-value reported ( $p = 0.824$ ), where  $p > 0.05$ . This implies that the combined effect of age group and race on attitudes toward driving was not statistically significant. Similarly, the interaction effects between sex and age group ( $\lambda = 0.973$ ;  $p = 0.985$ ) were not significant.

Overall, while there are indications of associations between the three independent variables, age group and attitudes toward driving, further research with larger sample sizes or different statistical tests may help clarify the role of such demographic factors in shaping attitudes toward driving among older adults in South Africa.

### **Perceived Barriers**

MANOVA tests were also used to determine the relationships between age, sex and race on perceived barriers. The results thereof are tabulated below.

Table 14: Multivariate Analysis Test Results concerning (Perceived barriers)

| Effect             | Test  | Value | F     | Effect | Error   | p     |
|--------------------|-------|-------|-------|--------|---------|-------|
|                    |       |       |       | df     | df      |       |
| Intercept          | Wilks | 1.000 |       | 0.000  |         |       |
| Sex                | Wilks | 1.000 |       | 0.000  |         |       |
| Age Group          | Wilks | 0.941 | 1.030 | 10.000 | 165.000 | 0.421 |
| Race               | Wilks | 1.000 |       | 0.000  |         |       |
| Sex*Age Group      | Wilks | 0.966 | 0.576 | 10.000 | 165.000 | 0.832 |
| Sex*Race           | Wilks | 1.000 |       | 0.000  |         |       |
| Age Group*Race     | Wilks | 0.727 | 1.374 | 40.000 | 627.516 | 0.066 |
| Sex*Age Group*Race | Wilks | 0.738 | 1.306 | 40.000 | 627.516 | 0.102 |

Illustrated in Table 15 above are the results of the MANOVA conducted for the demographics of age, sex and race for perceived barriers to driving. The multivariate analysis displayed a Wilks'  $\lambda$  value of 0.941 pertaining to the influence of age group on attitudes with an associated p-value ( $p = 0.421$ ), thus implying no significant difference between how different age groups view the perceived barriers, for example,

rain. Based on these findings, it would suggest that all age groups viewed the barrier of rain in the same light.

Statistical analysis was also conducted on the interaction effects between age and other demographic variables, including sex and race. The results indicated that none of these interaction effects, including those involving sex, age group, and race simultaneously, yielded statistically significant findings. As can be observed in Table 15 above, the Wilks'  $\lambda$  value for the interaction between age group and race was 0.727 with a corresponding p-value ( $p = 0.066$ ),  $p > 0.05$  implying that there was no significant difference. These non-significant results suggest that the combined influences of age group, sex, and race on perceived barriers did not differ between age, sex or race.

While seemingly conclusive results were acquired, it is recommended that further research be conducted with larger sample sizes to ascertain the true relationships between variables, thus giving a more balanced view of the country as a whole. that can be deduced from the data.

## CHAPTER 5: DISCUSSION

Ergonomics, as a scientific discipline, is often influenced by psychology-based theories. True as that may be, it was important for this research project to reiterate that while psychology principles were utilised, an ergonomics-specific context was key in addressing driver-related challenges within South Africa's ageing and older populations. At its core, this research project emphasised the importance of a transdisciplinary approach in contextualising key ergonomic-based concepts that translate into optimising systems design and ensuring the efficient performance of tasks.

The literature review explored psychological theories explaining the formation of habits, the role of practices in shaping behaviour, and how perceptions of humans interact with the highlighted system. Namely, the human-car-road system. A system characterised by complex and dynamic interactions (Carayon, 2006; Skyttner, 2005; Walker et al., 2010; Wilson, 2014).

This research project sought to explore how the role of sociodemographic factors such as age, sex and race affects the concepts of habits, practices and perceptions, concerning the task of driving, among South African drivers aged 55 years and above. Expanding on this information, a systems ergonomics framework was used to interpret the findings.

While driving is a global activity performed by many to get around, unique challenges affect drivers across geographical locations (Khosa', 1995; Kim et al., 2016; Stalvey et al., 2000). These challenges often represented country-specific economics and development, beliefs and societal norms. Gauteng's unique infrastructural and mobility landscape posed context-specific differences that were not consistent with Western research (Seekings & Nattrass, 2004; Khosa', 1995; Klauer et al., 2006; McCarthy, 1990; Moyo et al., 2021; Raitanen et al., 2003; Stanojević et al., 2018) .

Given the extensive research explored in the review of literature conducted by multiple experts (Albert et al., 2018; Donorfio et al., 2008; Koppel et al., 2016; Martinussen et al., 2014; Patel et al., 2008; Ram & Chand, 2016; Stalvey et al., 2000; Waller, 1991)

over decades, the DHQ and DPPQ were deemed suitable research tools that would guide the research question.

### **5.1 Driver Demographic Information**

Having gathered 205 participants from the Gauteng province, the demographic composition of the participants revealed a diverse sample in terms of sex, age group, and race, which is consistent with the province's diverse socio-economic background (Seekings & Natrass, 2004; Khosa', 1995; Oosthuizen & Pretorius, 2016) . The results obtained also provided insight into the broader sociotechnical system of driving in Gauteng.

In conjunction with the demographic information, participants were presented with questions regarding their opinions on their general health, driving abilities, and their opinions about their peers' driving capabilities. These opinions were recorded before the completion of DHQ and DPPQ, respectively.

It was found that participants across all age groups rated their driving abilities as predominantly "good" or "excellent." The veracity of this can be challenged as similar research has reported discrepancies between perceived and actual driving ability (Donorfio et al., 2008, 2009; Marottoli & Richardson, 1998). Donorfio (2008;2009), in particular, concluded that older drivers tended to overestimate their driving fitness and or confidence, despite objective declines in biological function. Similarly, a notable observation made by participants was the awareness that their health affected their driving capabilities. It was thus not only expected but reported that a significant percentage of the participant sample considered themselves to be skilled or good drivers.

Given that ageing is a phenomenon that occurs to all humans irrespective of race and sex, it was thus considered, based on our findings, that this too was the case with South African drivers. Discrepancies in self-reported vs more objectively attained research are not uncommon and can result in researchers having preconceived biases, thus distorting the results obtained.

## **5.2 The Role of Age, Race and Sex on Driver Habits, Practice and Perceptions**

The habits and practices of older drivers are shaped by a combination of factors, comprising age-related physical and cognitive changes, driving experience, and individual self-regulation strategies. Of the 205 participants, 199 participants reported that they were active drivers. Inactive drivers attributed, ill health, no access to personal motor vehicle as well as the COVID-19 mandated restrictions.

Health, vision, and chronic illness play a significant role in driving cessation among older adults, as they directly impact the physical and cognitive abilities required for safe driving. In this study, participants who reported health-related reasons for stopping driving commonly cited visual impairments and chronic illnesses such as diabetes. This finding aligned with existing literature, further highlighting the critical role of vision in driving safety. Thus, in conjunction with the literature, as well as the results obtained, it can be noted that conditions like chronic visual impairment-related illnesses (e.g. cataracts) or general age-related decline in visual acuity can severely limit an individual's ability to drive safely or be considered a safe driver (Anstey et al., 2005; Owlsley, C; Wood, 2015; Wood et al., 2016; Wood, 2002, 2019, 2020) . What this boiled down to, was the fact that health factors emphasised the importance of regular health screening and assessments.

With participants driving, on average approximately 6 days a week. This is believed to be a result of the differences in employment status and lifestyle demands. While these factors were taken note of during data collection, they were not fully explored in full as they were considered a direct effect of South Africa's past and current socioeconomic policies. Future research could benefit from further breaking down these factors. A typical work week in South Africa is 5 days. Within the different age groups of our population, it was expected that based on employment status and lifestyle demands, there would be differences in the amount of time spent on the road.

Quality of driving was determined by factors that include but are not limited to adherence to regulations, applied safety measures, and crash avoidance. Age was found to significantly influence certain driving habits and behaviours, proving consistency with global research on the relationship between ageing and driving capabilities (Baumeister & Heatherton, 1996; Devlin & McGillivray, 2014; Donorfio et

al., 2008). As expected, older participants (particularly those aged 66 and above) reported greater difficulty with certain driving tasks, such as night driving, parallel parking, and driving in rush-hour or highly congested traffic. These support findings that align with prior studies suggesting that ageing results in physical and cognitive decline, which impacts driving performance (Anstey et al., 2005, 2012; Ball et al., 1993; Owsley et al., 2001; Stalvey et al., 2000). Specifically, vision impairment and slower reaction times become more prevalent with age, influencing the avoidance of complex driving scenarios (Wood et al., 2013, 2018).

However, in this study, it was found that participants across all age groups rated their driving abilities as predominantly "good" or "excellent." This presented potential discrepancies between actual driving abilities and perceived driving abilities. Considering that self-regulation plays a critical role in road safety (Kaye et al., 2018; Sargent-Cox et al., 2011). While this discrepancy may be universal, South Africa's unique licensing and law enforcement-related corruption adds another layer that needs to be broken down to better understand the system at large (Larsson et al., 2010; Schermers et al., 2019; Traffic Focus, 2012) .

Contrary to much of the existing literature, in this study in particular, there were no significant sex differences concerning driving frequency, seatbelt use, or the wearing of corrective lenses while driving (Cordazzo et al., 2014; Cordellieri et al., 2016; Rhodes & Pivik, 2011). The same literature further suggested that men were more likely to engage in riskier driving behaviours, while, conversely, women were likely to be more cautious. The lack of significant sex differences could be attributed to the specific socio-geographic factors applicable to South Africa, possibly creating stark differences in comparison to Western countries. This consequently leaves the task of ongoing research into driving habits and associated behaviours, beyond the confines of sex-based tendencies alone.

Another key variable examined in this study was race. African participants made up the majority of the sample, accurately reflecting the demographic profile of South Africa (Statistics South Africa (Stats SA), 2021; StatsSA, 2017). Differences in driving habits and perceptions between racial groups were minimal, although it was observed that African participants reported fewer challenges related to vision compared to White participants. It is recommended that further investigation be conducted to determine

the validity of those results. The literature explored (Ball et al.1993; Owsley, 2016; Stalvey et al., 2000) made no assertions on vision-related challenges affecting different racial groups differently. Furthermore, the results obtained were all based on self-reported responses, which may have been overestimations of their health status or perhaps have just been in denial about. The results obtained from this study may be contentious and require a larger sample size or even include objective measures to establish whether or not race plays a significant role in the diagnosis of visual-related challenges or declines.

Contextually, different studies have shown that socioeconomic factors, which often intersect with race, can influence driving practices, including vehicle access and exposure to risky driving environments (Di Milia et al., 2011; Martin et al., 2017). For example, studies centred on rural versus urban living might reveal over or underrepresented results race or age-based results based on location. Location can snowball and reveal social disparities in service delivery. These disparities can determine things such as the amount of money spent on car maintenance due to road conditions. Studies conducted in the United States of America (Antoun et al., 2018; Cervero, 2013; Zhou & Wang, 2019) , showed correlations between driving behaviours and race and ethnicity. Particularly in urban settings, South Africa's historical socioeconomic disparities continue to shape access to resources, requiring different behavioural adaptation styles to ensure their mobility. Inferences from the works of Jassat (2022), informed by the works of Khosa (1995), McCarthy (1980) and Pellicer (2023).

As reported following the MANOVA results, the intersectionality of age, race and sex was found to significantly influence driving behaviours. The works of Gwyther and Holland (2012) support this as they stressed the importance of examining the relationship between the three sociodemographic factors and how they interact with each other to create distinctive experiences for individuals. For example, studies could look into how older African or Coloured women face different driving challenges or similarities from White or Indian Women based on pre- and post-apartheid geographical dispensation. Conversely, in studies in Western countries such as the United States, racial disparities in traffic law enforcement and accident rates are well-documented and more pronounced (Cox et al., 2014).

### 5.3 Systems Ergonomics

Systems ergonomics plays a critical role in ensuring that the driving system is responsive to the needs of ageing and older drivers. By focusing on the interactions between the human driver, the vehicle, and the road environment, systems ergonomics provides a holistic framework for understanding how ageing drivers interact with the broader driving environment. This environment also includes the presence of other vehicles, the road infrastructure and road traffic regulations.

By designing safer, more inclusive systems that accommodate the limitations of older adults while enhancing their ability to drive safely (Hubbard et al., 2010; Jassat et al., 2022; Righi & Saurin, 2015; Szabo & Birdsey, 2017; Wilson, 2014). As the population ages, these principles become steadily relevant for road safety and mobility policy, particularly in countries like South Africa, where infrastructure challenges and socio-economic disparities add additional complexity to the driving environment.

The human-car-road system functions optimally when all components work in unison to support the driver's abilities. In the context of ageing or older drivers, systems ergonomics underscores the importance of aligning these components to reduce the risk of accidents, enhance mobility and provide a level of confidence that makes them feel they are contributing positively to society (First, 2013; Jivraj et al., 2014; Waddell & Jacobs-Lawson, 2010). For example, a well-integrated system might include ergonomically designed cars that offer easy usability (e.g., easy-to-read displays and easy-to-use controls), carefully designed roads that bear in mind the abilities and challenges experienced by all drivers, and social systems that ensure drivers are regularly assessed for driving fitness.

The secondary aim of this study was to examine the role played by the ageing South African driver within the human-car-road system, using systems ergonomics principles. As emphasised in Chapter 2, no subsystem within complex systems can function in isolation. Instead, as the definition dictates, the elements of a system interact dynamically within defined boundaries, with each element being influenced and having influence on the other system's elements (Wilson, 2014). A holistic approach reinforces the need to move beyond a reductionist perspective that characterises older drivers solely as risky based on their age-related physical and

cognitive declines. While physiological decline may introduce vulnerabilities, this study showed that ageing drivers make important contributions to system safety through compensatory behaviours, thereby challenging narrow deficit-focused framings.

The key human element of the social subsystem is characterised by the ageing South African driver, whose role within the broader human-car-road system is not of a passive operator, but rather shaped by the interaction between physical and cognitive capabilities and years of driving experience (Wilson, 2014; Saurin & Gonzalez, 2013). Within the human-car-road system, age can be seen as a shaping variable and not just a chronological marker; it signifies the subsystem's broadened adaptive potential.

The results of this study demonstrated that age, sex, and race significantly influenced driver habits, perceptions, and practices, but age consistently emerged as the strongest determinant. Older drivers reported heightened caution, stricter adherence to road regulations, and selective avoidance of highly demanding or challenging driving situations such as driving at night or on busy highways. These findings resonate strongly with the principle of a systems focus (Wilson, 2014), which emphasises that the effectiveness of a system is not determined by the performance of its individual components in isolation, but by how their adaptations shape system-wide outcomes such as traffic density, safety patterns, and overall resilience.

The MANOVA analysis, as discussed in Chapter 4, showed that the main effect of age on current driving behaviour was significant ( $Wilks' \lambda = 0.9087$ ;  $F(3,177) = 5.93$ ;  $p < 0.001$ ), while also noting significant interaction effects involving age and sex, age and race, as well as age, sex and race (as shown in Tables 10-14). Those results ultimately showed that age interacts with sex and race to produce context-specific patterns. Taken together, the findings affirm that the ageing driver is a coupled element in a socio-technical system, whose performance depends on the interplay between subsystems.

These findings also highlight the significance of the interactions within the human-car-road system. The adaptive strategies shown by the older drivers illustrate how the social subsystem actively reshapes its exchanges with the technical subsystem to maintain stability and ultimately ensure that the system functions well (Brelet et al., 2016; Molnar et al., 2014; Siren & Meng, 2013). This occurs despite systemic shortcomings that can be seen within the context of the road network.

From the literature review, age was positioned as a determinant of driving performance due to its associated physical and physiological declines, as well as its compensatory strengths that arise due to experience (Cox et al., 2014; Gwyther & Holland, 2012; Rhodes & Pivik, 2011; Wood et al., 2018). The ageing driver thus has adaptive capacity, which can be tied to the principle of emergence (Mittal & Rainey, 2015; Righi & Saurin, 2015; Saurin & Gonzalez, 2013). Different behaviours emerge as drivers respond to changes in their capabilities, vehicle capabilities, performance, and environmental conditions (Anget et al., 2019; Ang, Oxley, et al., 2019; Devlin & McGillivray, 2014; Donorfio et al., 2009; Gwyther & Holland, 2012; Sullivan et al., 2011). The selective adoption of self-regulatory behaviours such as avoidance of nighttime driving, adjusting travel times and avoidance of high-risk conditions is an example of how the human subsystem responds to itself as a system (Botla & Kondur, 2018; Devlin & McGillivray, 2014; Hubbard et al., 2010; Wilson, 2014), the system at large and the constraints of both itself as a system and the broader system. The collective patterns of cautious driving and regulation adherence among older drivers ultimately contribute to a safety-oriented traffic culture, while the widespread avoidance of complex environments possibly also redistributes risks to other drivers. Similarly, mismatches between drivers' perceptions of their abilities and their objective risks can highlight the unpredictable and emergent qualities of sociotechnical systems.

Ultimately, the functions of the different elements- the social and the technical- and their own associated challenges and complexities, demonstrate the idea that system outcomes are not reducible to the properties of individual components, but arise from the dynamic interactions between subsystems (Saurin & Gonzalez, 2013; Walker et al., 2010; Wilson, 2014). Thus, the effects of age on driving behaviour are the emergent properties of the sociotechnical, human-car-road system, and reflect the alignment or misalignment of the different system components.

Within the broader human-car-road system, the vehicle and its functions interface between the driver and the environment. The environmental component of the technical subsystem, as outlined in Chapter 2, encompasses the road and road-network infrastructure and all its related policies. It is essential to recognise that a well-

designed and well-maintained road network system, combined with a robust legal framework, can foster a more efficient human-car-road system.

For instance, the literature review mentioned that a great focus was placed on visual acuity when obtaining a license. This alone, as a capability measurement tool, illustrates that there may be a need for policy reviews, as visual capabilities alone are not a sufficient measure of what ultimately makes one a “safe” driver. In the same breath, it can also be said that from the technical subsystem perspective, there is more to the task of driving than the driver's abilities; the technical subsystem is equally important (Biehler et al., 2008; Carayon, 2006; Wilson, 2014). Poor signage, inadequate road maintenance, insufficient lighting, and insufficient law enforcement ultimately place a greater workload on the individual driver. How they react to the dynamic environment in which they find themselves in. While the focus of this study is primarily on the human aspect of the sociotechnical subsystem, the literature and results indicate that the technical subsystem is highly complex and requires considerable attention. For the greater human-car-road system to function efficiently, safely and optimally, a lot of work needs to be done. This will include bringing stakeholders from various disciplines to better understand the technical subsystem and its challenges.

It is important to recognise that, because of the limited scope of this research, truly addressing the concept of embedding will require extensive input from legislative authorities, road engineering authorities and other professionals. This is because the human-car-road system is embedded in broader societal, institutional, and cultural structures. The observed differences across demographic lines are not isolated phenomena but are also reflections of historical inequalities, gender norms and cultural norms around mobility and independence (outside of the act of driving). Embedding emphasises the need to interpret the ageing driver not only in terms of individual capability but as part of a tight hierarchy of systems that extend from micro-level interactions with vehicles to macro-level policy frameworks and societal structures.

From a systems ergonomics perspective, effective driving and effective interventions should target the system as a whole rather than focusing exclusively on the driver. Fully understanding the role of the ageing driver on a large scale cannot be understood without considering the mutual dependencies of the entire sociotechnical system, i.e. the human-car-road system. While the human element of the system brings with it both limitations and resultant adaptive strategies, the non-human elements can offset or exacerbate them and bring constraints.

Wilson's (2014) six characteristics of systems ergonomics emphasise the active, adaptive role played by ageing South African drivers within the human-car-road system. The implications are significant in that interventions a) should not and cannot narrowly frame older drivers as liabilities, but rather b) design systemwide strategies that distribute responsibility across subsystems. Improvements in road infrastructure, context-specific and sensitive vehicle technologies, equitable and practical law enforcement, and well-informed, supportive driver education can reduce the adaptive burden on individuals while strengthening system resilience. By embedding ageing drivers within a holistic, systems-based understanding, South Africa can move toward a safer, more inclusive, and ergonomically sound transport system.

## CHAPTER 6: CONCLUSIONS

### 6.1 Conclusion

In summary, this thesis contributed valuable insights into the driving behaviours of South African drivers over the age of 55, highlighting the roles of age, sex, and race in shaping self-regulatory practices, day-to-day habits and perceptions. As the general population shifts towards an older population, it is essential to comprehend the unique challenges and necessary adjustments faced by adult drivers aged 55 years and older. Understanding this is crucial for enhancing road safety and fostering personal autonomy. Based on the age of the participants, it can be said that future studies should also look into the habits, perceptions and practices of younger drivers to determine differences and similarities, allowing comparisons to be made.

The findings from this study revealed that age was the most significant determinant of driving behaviour, with older participants demonstrating increased self-regulation by avoiding challenging conditions such as nighttime driving and rush-hour traffic. However, despite physical and cognitive declines, many ageing drivers continued to rate their driving abilities as "good" or "excellent," highlighting a potential gap between perceived driving capabilities and actual driving capabilities. The study also found subtle but sex differences, with older men being less likely to self-regulate compared to older women, a pattern in alignment with international literature suggesting that gendered attitudes, gender roles and socialisation affect driver independence and risk-taking behaviour. Racial differences were primarily observed in vision-related challenges and self-regulation tendencies, possibly mirroring South Africa's socioeconomic disparities. Thus, it requires further investigation into readily available South African visual health or optometric information.

The Gauteng context added a layer of complexity to the findings, as the province's dense urban environment, high traffic congestion, and limited public transport alternatives suggested that many older adults continued driving out of necessity rather than choice. This contrasts with Western countries, where efficient public transport systems and alternative mobility options allow ageing drivers to transition away from driving more seamlessly.

The application of systems ergonomics principles in designing safer, more supportive driving environments and policies for older adults is critical to enhancing road safety, which is complex and requires a multi-disciplinary approach to understanding the greater South African road network system. This research provides a foundation for further studies that may inform more inclusive transportation policies and interventions in South Africa, aiming to improve the safety and well-being of ageing drivers and the broader community.

## **6.2 Recommendations**

This study demonstrated that age, sex, and race each play a meaningful role in shaping driving practices and safety perceptions among older South African drivers. By providing an evidence-based understanding of these interactions, the study can be expanded to inform future policy decisions and road safety interventions that will best suit South Africa. In doing so, it contributes to a foundation for further research and underscores the need for adaptive strategies that promote safe driving and support the evolving needs of an ageing population in South Africa and beyond.

The recommendations presented are aimed firstly at addressing driving regulations and ensuring that they appropriately and safely accommodate older drivers. And licensing concerns. Secondly, to open up future research to include multi-disciplinary approaches to better understand the system at large, making South African roads safer for everyone.

Concerning licensing, it is recommended that the licensing departments look into conducting medical check-ups over and above simple vision testing when license renewals are done. This is to ensure that licensed drivers are not only fit to drive but also to reduce the likelihood of unsafe driving practices and possible accidents. It is also recommended that driving refresher courses and evaluations be legislated for drivers over a particular age (e.g. over 60 years old). In conjunction to this, it is recommended that the government create awareness programs around the safety of driving with increasing age and its associated health declines.

Future research will be necessary to expand upon this current study. It is recommended that longitudinal studies, be conducted on the mobility of South African drivers. This would not only improve the validity of future studies while allowing researchers to compare and contrast similar studies in developed countries. The comparison of research is presumed to be effective in delivering invaluable insights into better accommodating different demographics of drivers within the broader South African road network system. This can facilitate the planning of interventions and better infrastructural planning inclusive of all licensed drivers. This can only be possible by adopting a multi-disciplinary team of experts such as ergonomists, doctors, civil engineers and town planners.

Furthermore, research can be conducted to investigate the role of sociodemographic factors unique to a South African context for an inclusive transportation framework. This will facilitate access to safe and efficient transportation. Additional research conducted can be used to inform the modification of driving regulations that will rectify specified disparities caused by sociodemographic factors while providing insight into systems ergonomics principles to address holistic transport-related issues that apply to South Africa.

The proposed recommendations seek to establish a driving environment in South Africa that is supportive, flexible, and secure for older drivers. These measures address the difficulties linked to age-related impairments while simultaneously enhancing road safety and overall quality of life. It is believed that the implementation of specific regulatory reforms will lead to the improvement of public health initiatives and the promotion of alternative transportation options. Developing a more inclusive transportation system that caters to the needs of ageing and older drivers. The suggestions presented emphasise the importance of a comprehensive systems ergonomics approach in understanding mobility.



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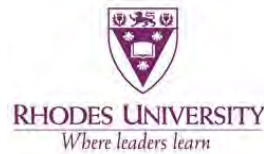
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# APPENDICES

## Appendix A1: Ethical Clearance Letter



**Rhodes University Human Ethics Committee**  
PO Box 94, Makhanda, 6140, South Africa  
t: +27 (0) 46 603 7727  
f: +27 (0) 46 603 8822  
e: [s.manqele@ru.ac.za](mailto:s.manqele@ru.ac.za)  
NHREC Registration number: RC-241114-045

<https://www.ru.ac.za/researchgateway/ethics/>

21/02/2021

Miss Bonolo Maloma

Human Kinetics and Ergonomics

Email: [g15m1780@campus.ru.ac.za](mailto:g15m1780@campus.ru.ac.za)

Review Reference: 2021-1599-5931

Dear Dr Swantje Zschemack

**Title:** A system's approach to understanding emerging characteristics exhibited by the ageing adult population (55+) of drivers as a result of ageing.

**Principal Investigator:** Dr Swantje Zschemack

**Collaborators:** Miss Bonolo Maloma,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Human Ethics Committee (RU-HEC). Your Approval number is: 2021-1599-5931

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloging number allocated.

Sincerely,

**Prof Arthur Webb**

**Chair: Rhodes University Human Ethics Committee, RU-HEC**

cc: Mr. Siyanda Manqele - Ethics Coordinator

Appendix A2: Request for Permission to Conduct Research



Rhodes University  
Drostdy Road,  
Grahamstown,  
6139

.....  
.....  
Private Bag  
.....

Date

Dear Ms/Mr

**REQUEST FOR PERMISSION TO CONDUCT RESEARCH**

I am a registered Masters student in the Department of **Human Kinetics and Ergonomics** at the Rhodes University. My supervisor is **Dr Swantje Wells**

The proposed topic of my research is A System's Approach to Understanding Emerging Driver Habits, Perceptions and Practice:s Exhibited by Ageing South African Drivers: The Effects of Age, Sex and Race on Driving.

- (a) To investigate how the biological and social aspects of ageing affect the human element of the human-car-road system
- (b) To identify the emerging characteristics that are identified and how they affect the system at large.

I am hereby seeking your consent to take part in completing the two questionnaires that will allow me to gain insight into my aim and objectives. To assist you in reaching a decision, I have attached to this letter:

- (a) A copy of an ethical clearance certificate issued by the University
- (b) A copy the research instruments which I intend using in my research

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows:

*Bonolo Maloma*

Human Kinetics and Ergonomics  
Department, Rhodes University,  
Grahamstown, South Africa, 6140

g15m1780@campus.ru.ac.za

*Dr Swantje Wells (Supervisor)*

Human Kinetics and Ergonomics  
Department, Rhodes University,  
Grahamstown. South Africa. 6140

s.wells@ru.ac.za

Upon completion of the study, I undertake to provide you with a feedback

Your permission to conduct this study will be greatly appreciated.

Yours sincerely,

**Signature**

A handwritten signature in black ink, appearing to be the initials 'BM' with a long horizontal stroke extending to the right.

Ms. Bonolo Maloma (MSc Candidate)

## Appendix A3: Information to Participants Letter



Human Kinetics and Ergonomics Department, Rhodes University, Grahamstown,  
Eastern Cape, Rhodes University

Bonolo Maloma, [g15m1780@campus.ru.ac.za](mailto:g15m1780@campus.ru.ac.za), 076 789 3740

Dr Swantje Zschoernack (Principal Investigator), [s.zschoernack@ru.ac.za](mailto:s.zschoernack@ru.ac.za), 046 603  
8472

### Information To Participants Letter

Dear Participant, thank you for your interest in participating in my study titled “**A System’s Approach to Understanding Emerging Driver Habits, Perceptions and Practices Exhibited by Ageing South African Drivers: The Effects of Age, Sex and Race on Driving.**” As alluded to in the title, this research project’s main aim is to identify self-regulating behaviours that older adults may or may not adopt while driving based on age, sex and race.

#### Brief Background

Modern day life requires the need for people to be able to commute between various places, for various reasons throughout the course of each day. Driving is one manner in which people travel between destinations. Driving a car is a complex task, wherein the driver is exposed to visual, auditory and tactile stimuli from both the car as well as the road. Ninety-five percent of driving accidents are attributed to human error. There is an increase in the number of older adults driving, this requires that more research be done to understand the older driver, their driving habits as well as the safety concerns that may or may not result.

The question of whether to drive or not to drive amongst older people brings about issues of safety, legality and independence. Driving requires a good situational

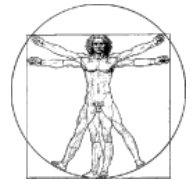
awareness, good vision as well as sound decision making. With increasing age, humans begin to experience visual defects, a decrease in physical strength as well as possible decrements where cognitive health applies. The focus of this research will thus look into understanding the older driver, and how the changes that may come with ageing not only affect their driving performance, but their willingness to drive, and the conditions within they are willing to drive under.

What will be required of you

As the participant you will be required to fill out two questionnaires, namely the *Driver Perception and Practices Questionnaire* and the *Driving Habits Questionnaire*. The main purpose of these questionnaires is for you to report on the driving behaviours applicable to yourself as well to share your views on driving and shed some light on how and why people drive. Both questionnaires should take you roughly 30 minutes to complete. All personal information that will be provided by yourself shall be kept confidential and will be disposed of once the research project has been completed. A record of the data collected (the questionnaires), however, will be archived by the Department of Human Kinetics and Ergonomics at Rhodes University and later be discarded after a five year period. Should you wish to receive feedback once the study has been completed, please make that known to the researcher and an email shall be sent to you.

Risks and Benefits

While there are no physical risks associated with this research project, there are notable benefits. Some of these benefits include contributing towards the body knowledge where roads safety is concerned, helping the South African licensing departments more aware of the type of drivers on our roads, which in turn will help promote safe driving.



## PARTICIPANT INFORMED CONSENT

### INFORMED CONSENT DECLARATION (Participant)

**Project Title: A System's Approach to Understanding Emerging Driver Habits, Perceptions and Practices Exhibited by Ageing South African Drivers: The Effects of Age, Sex and Race on Driving.**

*(Ms Bonolo Maloma)* from the Department of Human Kinetics and Ergonomics, Rhodes University has requested my permission to participate in the research mentioned above project.

The nature and the purpose of the research project and of this informed consent declaration have been explained to me in a language that I understand.

I am aware that:

1. The purpose of the research project are two-fold. Namely, to identify the habits, perceptions and practices of ageing South African drivers based on race, age and sex. The secondary aim was then to investigate the role played by the ageing South African driver within the human-car-road system by using systems ergonomics principles.
2. The Rhodes University has given ethical clearance to this research project, and I have seen/ may request to see the clearance certificate.
3. By participating in this research project, I will be contributing towards *gaining a better understanding into the role that ageing adult drivers play in driving safety and performance research. With the ageing population continuing to drive it is important to understand the challenges facing this demographic and how safe driving can be maintained or improved. While most adult drivers will meet the visual criteria required by the licensing centres around the country, multiple other factors may play a role in understanding the ageing or elderly South African driver. This research can thus help paint a picture concerning understanding the elderly drivers, ensuring their safety as well as the safety of other road users, and overall helping to shape legislature pertaining to Road and Traffic Safety.*

4. I will participate in the project by *Filling out Two Questionnaires Namely the **Driving Habits Questionnaire** and the **Driver Perceptions and Practices Questionnaire**. The two questionnaires will provide insight into the beliefs and practices exhibited by elderly drivers as well bringing light to the habits that may be present within the older driving community.*
5. My participation is entirely voluntary and should I at any stage wish to withdraw from participating further, I may do so without any negative consequences.
6. I will not be compensated for participating in the research, but my out-of-pocket expenses will be reimbursed. (**No out-of-pocket expenses will be incurred from this research project**)
7. The researcher intends to publish the research results in the form of a finalised MSc Thesis submitted to Rhodes University. However, confidentiality and anonymity of records will be maintained and my name and identity will not be revealed to anyone who has not been involved in the conduct of the research.
8. I will not receive feedback regarding the results obtained during the study, but I will receive feedback in the form of an email.
9. Any further questions that I might have concerning the research or my participation will be answered by myself Bonolo Maloma (076 789 3740 or @bmaloma@gmail.com).
10. By signing this informed consent declaration, I am not waiving any legal claims, rights or remedies.
11. A copy of this informed consent declaration will be given to me, and the original will be kept on record.

I, ..... have read the above information / confirm that the above information has been explained to me in a language that I understand, and I am aware of this document's contents. I have asked all questions that I wished to ask, and these have been answered to my satisfaction. I fully understand what is expected of me during the research.

I have not been pressurised in any way and I voluntarily agree to participate in the project mentioned above.

.....  
**Participant's signature**

.....  
**Witness**

.....  
**Date**

Rhodes University, Research Office, Ethics  
Ethics Coordinator: [ethics-committee@ru.ac.za](mailto:ethics-committee@ru.ac.za)  
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707  
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

## APPENDIX A5: Participant Details Form

### Participant Demographics and General Questions

*To be completed prior to the DHQ and the DPPQ*

**Participant code:** \_\_\_\_\_

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#### Demographic Information

##### Sex

|      |        |
|------|--------|
| Male | Female |
|------|--------|

##### Age Group (years)

|              |             |             |            |           |
|--------------|-------------|-------------|------------|-----------|
| 55- 59 years | 60-65 years | 66-70 years | 71-79years | 80+ years |
|--------------|-------------|-------------|------------|-----------|

##### Race

|         |       |          |        |       |
|---------|-------|----------|--------|-------|
| African | White | Coloured | Indian | Other |
|---------|-------|----------|--------|-------|

##### Employment status

|  |            |           |
|--|------------|-----------|
| Employed (Self-employed, Part or full time employment) | Unemployed | Pensioner |
|--|------------|-----------|

##### Highest level of education

|                      |                 |                                 |                                |
|----------------------|-----------------|---------------------------------|--------------------------------|
| High school or lower | College Diploma | University Undergraduate degree | University Postgraduate degree |
|----------------------|-----------------|---------------------------------|--------------------------------|

**Province of residence** \_\_\_\_\_

**Type of Regional Residence**

|       |          |      |      |
|-------|----------|------|------|
| Rural | Township | Town | City |
|-------|----------|------|------|

**Regional area of work**

|       |          |      |      |
|-------|----------|------|------|
| Rural | Township | Town | City |
|-------|----------|------|------|

**Type(s) of region in which you frequently drive? (may mark more than one)**

|       |          |      |      |
|-------|----------|------|------|
| Rural | Township | Town | City |
|-------|----------|------|------|

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**Pre Questionnaire Questions**

**How would you rate your driving ability?**

|      |               |      |           |
|------|---------------|------|-----------|
| Poor | Fair/ average | Good | Excellent |
|------|---------------|------|-----------|

**Do you consider yourself a safe driver?**

|     |    |
|-----|----|
| Yes | No |
|-----|----|

**Do you think that good health affects driving?**

|     |    |
|-----|----|
| Yes | No |
|-----|----|

**How would you rate your overall health?**

|      |               |      |           |
|------|---------------|------|-----------|
| Poor | Fair/ average | Good | Excellent |
|------|---------------|------|-----------|

**Do you think your general health affects your driving ability?**

|     |    |
|-----|----|
| Yes | No |
|-----|----|

**Do you think vision is important for driving?**

|     |    |
|-----|----|
| Yes | No |
|-----|----|

**How would you rate your vision ?**

|      |               |      |           |
|------|---------------|------|-----------|
| Poor | Fair/ average | Good | Excellent |
|------|---------------|------|-----------|

**Do you think the process of ageing makes you a bad driver?**

|     |    |
|-----|----|
| Yes | No |
|-----|----|

**Do you think it is appropriate to deny older adults the right to drive?**

|     |    |
|-----|----|
| Yes | No |
|-----|----|

Appendix A6: Driver Habits Questionnaire

Driver Habits Questionnaire (DHQ)

Dear Participants please fill out the Questions below. Different sections may require different responses, please read the instructions carefully and use the provided space to answer the questions.

**Current Driving**

1. Do you currently drive?

- \_\_\_\_\_ (1) yes (**go to question #4**)
- \_\_\_\_\_ (0) no (**go to questions #2 and #3 only**)

2. Why did you stop driving?

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3. When is the last time you drove? \_\_\_\_\_ (month/year)  
**(if within this current year go to question #25)**

4. Do you wear glasses or contact lenses when you drive?

- \_\_\_\_\_ (1) yes
- \_\_\_\_\_ (0) no

5. Do you wear a seatbelt when you drive?

- \_\_\_\_\_ (1) always
- \_\_\_\_\_ (2) sometimes
- \_\_\_\_\_ (3) never

6. Which way do you prefer to get around?

- \_\_\_\_\_ (3) drive yourself
- \_\_\_\_\_ (2) have someone drive you
- \_\_\_\_\_ (1) use public transportation or a taxi

7. How fast do you usually drive compared to the general flow of traffic? Would you say:

- \_\_\_\_\_ (5) Much faster
- \_\_\_\_\_ (4) Somewhat fast
- \_\_\_\_\_ (3) About the same
- \_\_\_\_\_ (2) Somewhat slower
- \_\_\_\_\_ (1) Much slower

8. Has anyone suggested over the past year that you limit your driving or stop driving?

- \_\_\_\_\_ (1) yes
- \_\_\_\_\_ (0) no

9. How would you rate the quality of your driving? Would you say:

- \_\_\_\_\_ (5) Excellent
- \_\_\_\_\_ (4) Good
- \_\_\_\_\_ (3) Average
- \_\_\_\_\_ (2) Fair
- \_\_\_\_\_ (1) Poor

10. If you had to go somewhere and didn't want to drive yourself, what would you do?

Would you:

- \_\_\_\_\_ (1) Ask a friend or relative to drive you
- \_\_\_\_\_ (2) Take public transportation
- \_\_\_\_\_ (3) Drive yourself regardless of how you feel
- \_\_\_\_\_ (4) Cancel or postpone your plans and stay home
- \_\_\_\_\_ (5) Other (specify):

\_\_\_\_\_

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### **Exposure**

11. In an average **week**, how many days do you normally drive?

\_\_\_\_\_ number of days per week

### **Avoidance**

**Interviewer:** Use **Answer Sheet A** for questions **17 thru 24**

**17a)** During the past 3 months, have you driven when it is raining?

\_\_\_\_\_ Yes (**go to 17b**)

\_\_\_\_\_ No (**go to 17c**)

**17b)** Would you say that you drive your car when it is raining with:  
do not  
(Please check only **one** answer)

- No
- 5 \_\_\_\_\_ No difficulty at all
  - 4 \_\_\_\_\_ A little difficulty
  - 3 \_\_\_\_\_ Moderate difficulty
  - 2 \_\_\_\_\_ Extreme difficulty

**17c)** Is it mostly because of visual problems that you do not drive when it is raining?

- 1 \_\_\_\_\_ Yes \_\_\_\_\_  
(go to 18a)(go to 18a)

**18a)** During the past 3 months, have you driven alone?

- \_\_\_\_\_ Yes (go to 18b)                      \_\_\_\_\_ No (go to 18c)

**18b)** Would you say that you drive alone with:  
(Please check only **one** answer)

- No
- 5 \_\_\_\_\_ No difficulty at all
  - 4 \_\_\_\_\_ A little difficulty
  - 3 \_\_\_\_\_ Moderate difficulty
  - 2 \_\_\_\_\_ Extreme difficulty

**18c)** Is it mostly because of visual problems that you do not drive alone?

- 1 \_\_\_\_\_ Yes \_\_\_\_\_  
(go to 19a)(go to 19a)

**19a)** During the past 3 months, have you parallel parked?

- \_\_\_\_\_ Yes (go to 19b)                      \_\_\_\_\_ No (go to 19c)

**19b)** Would you say that you do not parallel park with:  
(Please check only **one** answer)

- No
- 5 \_\_\_\_\_ No difficulty at all
  - 4 \_\_\_\_\_ A little difficulty
  - 3 \_\_\_\_\_ Moderate difficulty
  - 2 \_\_\_\_\_ Extreme difficulty

**19c)** Is it mostly because of visual problems that you do not parallel park?

- 1 \_\_\_\_\_ Yes \_\_\_\_\_  
(go to 20a) (go to 20a)

**19.**

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**21a)** During the past 3 months, have you driven on highways?

\_\_\_\_\_ Yes (**go to 21b**)

\_\_\_\_\_ No (**go to 21c**)

**21b)** Would you say that you drive on highways with:  
(Please check only **one** answer)

- 5 \_\_\_\_\_ No difficulty at all
- 4 \_\_\_\_\_ A little difficulty
- 3 \_\_\_\_\_ Moderate difficulty
- 2 \_\_\_\_\_ Extreme difficulty

**21c)** Is it mostly because of your visual problems that you do not drive on interstates?

- 1 \_\_\_\_\_ Yes \_\_\_\_\_ No  
(**go to 22a**) (**go to 22a**)

**22a)** During the past 3 months, have you driven on high-traffic roads?

\_\_\_\_\_ Yes (**go to 22b**)

\_\_\_\_\_ No (**go to 22c**)

**22b)** Would you say that you drive on high-traffic roads with:  
(Please check only **one** answer)

- 5 \_\_\_\_\_ No difficulty at all
- 4 \_\_\_\_\_ A little difficulty
- 3 \_\_\_\_\_ Moderate difficulty
- 2 \_\_\_\_\_ Extreme difficulty

**22c)** Is it mostly because of your visual problems that you do not drive on high-traffic roads?

- 1 \_\_\_\_\_ Yes \_\_\_\_\_ No  
(**go to 23a**) (**go to 23a**)

**23a)** During the past 3 months, have you driven in rush-hour traffic?

\_\_\_\_\_ Yes (**go to 23b**)

\_\_\_\_\_ No (**go to 23c**)

**23b)** Would you say that you drive in rush-hour traffic with:  
(Please check only **one** answer)

- 5 \_\_\_\_\_ No difficulty at all
- 4 \_\_\_\_\_ A little difficulty
- 3 \_\_\_\_\_ Moderate difficulty
- 2 \_\_\_\_\_ Extreme difficulty

**23c)** Is it mostly because of your visual problems that you do not drive in rush-hour?

No

- 1 \_\_\_\_\_ Yes \_\_\_\_\_

(**go to 24a**) (**go to 24a**)

**24a)** During the past 3 months, have you driven at night?

\_\_\_\_\_ Yes (**go to 24b**)

\_\_\_\_\_ No (**go to 24c**)

**24b)** Would you say that you drive at night with:  
(Please choose only **one** answer).

- 5 \_\_\_\_\_ No difficulty at all
- 4 \_\_\_\_\_ A little difficulty

**24c)** Is it mostly because of your visual problems that you do not drive at night?

- 1 \_\_\_\_\_ Yes \_\_\_\_\_ No  
(**go to 25**) (**go to 25**)

- 3 \_\_\_\_\_ Moderate difficulty  
2 \_\_\_\_\_ Extreme difficulty

### **Crashes and Citations**

25. How many accidents have you been involved in over the past year when you were the driver? Please give an account of all accidents whether or not you were at fault.

\_\_\_\_\_ accidents

26. How many accidents have you been involved in over the past year when you were the driver and the police were called to the scene?

\_\_\_\_\_ accidents

27. How many times in the past year have you been pulled over by the police/traffic officers, regardless of whether you received a ticket?

\_\_\_\_\_ times

28. How many times in the past year have you received a traffic ticket (other than a parking ticket) where you were found to be guilty, regardless whether or not you think you were at fault?

\_\_\_\_\_ times

### **Driving Space**

29. During the past year, have you driven in your immediate neighbourhood?

(1) \_\_\_\_\_ Yes  
(0) \_\_\_\_\_ No

30. During the past year, have you driven to places beyond your neighbourhood?

(1) \_\_\_\_\_ Yes  
(0) \_\_\_\_\_ No

31. During the past year, have you driven to neighbouring towns or cities?

(1) \_\_\_\_\_ Yes  
(0) \_\_\_\_\_ No

32. During the past year, have you driven to more distant towns or cities?

(1) \_\_\_\_\_ Yes  
(0) \_\_\_\_\_ No

33. During the past year, have you driven to places outside of the province?

(1) \_\_\_\_\_ Yes  
(0) \_\_\_\_\_ No

Appendix A7: Driver Perceptions and Practices (DPPQ)

Driver Perceptions and Practices Questionnaire (DPPQ)

Dear Participants, please fill out the Questions below. Different sections may require different responses, please read the instructions carefully and use the provided space to answer the questions

**Please complete the following questions by writing the number of the corresponding response in the space provided.**

**Responses: (1) Strongly Agree; (2) Agree; (3) Disagree; (4) Strongly Disagree**

**Impact of vision on driving: Responses: (1) Strongly Agree; (2) Agree; (3) Disagree; (4) Strongly Disagree**

1. Your eyes can change enough as you grow older to affect your ability to drive
  
2. An individual will be able to notice when his or her vision changes.

**Concern for health and safety:**

*Responses: (1) Strongly Agree; (2) Agree; (3) Disagree; (4) Strongly Disagree*

3. All things considered; good health is important to me.

**Attitudes towards driving:**

*Responses: (1) Strongly Agree; (2) Agree; (3) Disagree; (4) Strongly Disagree*

4. The drivers of automobiles are best qualified to judge their own physical fitness to drive cars
  
5. No person should be denied the right to drive an automobile.
  
6. Every motorist should be required to pass a driving-skill test once in five years to continue to drive.
  
7. Drivers who take chances eventually become the expert drivers.
  
8. Persons with many years of driving should not be required to submit to examination in later years

9. Because 'things just happen' one should not be concerned with the prevention of accidents
10. The occurrence of accidents is a matter of chance and should be regarded as unavoidable.
11. Possession of a driver's license is evidence of the ability of the individual to drive safely
12. The sturdy construction of automobiles assures my safety at any speed.
13. It doesn't matter when or where you drive, your chances of having an accident are still the same.
14. I should not have to plan when and where to drive.
15. Changing the way I drive would take too much thought, I don't want to have to think about my driving
16. I should just be able to get in the car and go somewhere whenever I feel like it.

**Perceived barriers:**

*Responses: (1) Strongly Agree; (2) Agree; (3) Disagree; (4) Strongly Disagree*

17. Changing when/where I drive is not possible given my lifestyle and the places I need to go
18. Changing when/where I drive is not possible because of how I have to get from one place to another.
19. Changing when and where I drive is not possible because other people count on me to drive them.
20. Changing when and where I drive is not possible because public transportation is not available to me.
21. Changing when and where I drive is not possible because I don't want to use public transportation.
22. Changing when and where I drive is not possible because my friends/family members are unavailable.

- 23. Changing when and where I drive is not possible because I don't want to ask family/ friends to drive.
- 24. Changing my own driving habits is something that I can do to reduce my chances of being in a crash.
- 25. I would feel more protected against having an accident if I avoided challenging driving situations.
- 26. Other friends/family members riding with me would feel more protected, and safer if I avoided situations.

|  |
|--|
|  |
|  |
|  |

## APPENDIX B: Summary Statistics (Statistica)

| Descriptive Statistics (Sheet1 in MSc Data (Questionnaires) BMaloma(10Feb)) |          |          |          |          |     |                  |
|---|----------|----------|----------|----------|-----|------------------|
| Variable  | Mean     | Std.Dev  | Minimum  | Maximum  | N   | No.cases Missing |
| Sex   | 1.5220   | 0.500741 | 1.0000   | 2.0000   | 205 | 0                |
| Age Group   | 101.9366 | 0.823001 | 101.0000 | 104.0000 | 205 | 0                |
| Race  | 1.4020   | 0.732898 | 1.0000   | 4.0000   | 204 | 1                |

| Frequency table: Do you drive? (Sheet1 in MSc Data (Questionnaires) BMaloma(10Feb)) |       |                  |          |                    |
|---|-------|------------------|----------|--------------------|
| Category  | Count | Cumulative Count | Percent  | Cumulative Percent |
| No  | 5     | 5                | 2.43902  | 2.4390             |
| Yes   | 199   | 204              | 97.07317 | 99.5122            |
| Missing   | 1     | 205              | 0.48780  | 100.0000           |

| Frequency table: Do you wear glasses or contact lenses when you drive? (Sheet1 in MSc Data (Questionnaires) BMaloma(10Feb)) |       |                  |          |                    |
|---|-------|------------------|----------|--------------------|
| Category  | Count | Cumulative Count | Percent  | Cumulative Percent |
| No  | 148   | 148              | 72.19512 | 72.1951            |
| Yes   | 56    | 204              | 27.31707 | 99.5122            |
| Missing   | 1     | 205              | 0.48780  | 100.0000           |

## APPENDIX C1: Within-group Correlations

| Within-Group Correlations<br>Group: Sex:Female Age Group:60-65 years Race:African<br>Marked correlations are significant at $p < .05000$ |  |  |  |   |
|--|--|--|--|---|
|  | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving? | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>   |  |  |  |   |
| Which way do you prefer to get around?   | 1.000                                  | -0.692   | -0.051   | 0.760   |
| Has anyone suggested over the past year that you limit your driving or stop driving?   | -0.692                                 | 1.000  | 0.512  | -0.572  |
| If you had to go somewhere and didn't want to drive yourself, what would you do?   | -0.051                                 | 0.512  | 1.000  | -0.389  |
| How would you rate the quality of your driving?  | 0.760                                  | -0.572   | -0.389   | 1.000   |

| Within-Group Correlations<br>Group: Sex: Female Age Group:60-65 years Race:White<br>Marked correlations are significant at $p < .05000$ |  |  |  |   |
|---|--|--|--|---|
|   | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving? | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>  |  |  |  |   |
| Which way do you prefer to get around?  |  |  |  |   |
| Has anyone suggested over the past year that you limit your driving or stop driving?  |  | 1.000  | 1.000  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?  |  | 1.000  | 1.000  |   |
| How would you rate the quality of your driving?   |  |  |  |   |

| Within-Group Correlations<br>Group: Sex: Female Age Group:55-59 years Race: African<br>Marked correlations are significant at $p < .05000$ |  |  |  |   |
|--|--|--|--|---|
|  | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving? | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>   |  |  |  |   |
| Which way do you prefer to get around?   | 1.000                                  | -1.000   | 0.000  | 0.724   |
| Has anyone suggested over the past year that you limit your driving or stop driving?   | -1.000                                 | 1.000  | 0.000  | -0.724  |
| If you had to go somewhere and didn't want to drive yourself, what would you do?   | 0.000                                  | 0.000  | 1.000  | 0.000   |
| How would you rate the quality of your driving?  | 0.724                                  | -0.724   | 0.000  | 1.000   |

| Within-Group Correlations<br>Group: Sex:Female Age Group:55-59 years Race:White<br>Marked correlations are significant at $p < .05000$ |  |  |  |   |
|--|--|--|--|---|
|  | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving? | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>   |  |  |  |   |
| Which way do you prefer to get around?   | 1.000                                  |  | -0.289   | 0.194   |
| Has anyone suggested over the past year that you limit your driving or stop driving?   |  |  |  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?   | -0.289                                 |  | 1.000  | -0.671  |
| How would you rate the quality of your driving?  | 0.194                                  |  | -0.671   | 1.000   |

| <b>Within-Group Correlations</b><br><b>Group: Sex:Male Age Group:60-65</b><br><b>years Race:African</b><br><b>Marked correlations are significant at p &lt; .05000</b> |  |   |  |   |
|--|--|---|--|---|
|  | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>   |  |   |  |   |
| Which way do you prefer to get around?   | 1.000                                  |   | 0.192  | <b>0.670</b>                                    |
| Has anyone suggested over the past year that you limit your driving or stop driving  |  |   |  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?   | 0.192                                  |   | 1.000  | 0.014   |
| How would you rate the quality of your driving?  | <b>0.670</b>                           |   | 0.014  | 1.000   |

| <b>Within-Group Correlations</b><br><b>Group: Sex:Male Age Group:60-65</b><br><b>years Race:White</b><br><b>Marked correlations are significant at p &lt; .05000</b> |  |   |  |   |
|--|--|---|--|---|
|  | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>   |  |   |  |   |
| Which way do you prefer to get around?   | 1.000                                  |   | -0.816   | -0.577  |
| Has anyone suggested over the past year that you limit your driving or stop driving  |  |   |  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?   | -0.816                                 |   | 1.000  | 0.000   |
| How would you rate the quality of your driving?  | -0.577                                 |   | 0.000  | 1.000   |

| <b>Within-Group Correlations</b><br><b>Group: Sex:Male Age Group:60-65</b><br><b>years Race:Indian</b><br><b>Marked correlations are significant at p &lt; .05000</b> |  |   |  |   |
|---|--|---|--|---|
|   | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>  |  |   |  |   |
| Which way do you prefer to get around?  |  |   |  |   |
| Has anyone suggested over the past year that you limit your driving or stop driving   |  |   |  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?  |  |   | 1.000  | 0.000   |
| How would you rate the quality of your driving?   |  |   | 0.000  | 1.000   |

| <b>Within-Group Correlations</b><br><b>Group: Sex:Male Age Group:66-70</b><br><b>years Race:African</b><br><b>Marked correlations are significant at p &lt; .05000</b> |  |   |  |   |
|--|--|---|--|---|
|  | Which way do you prefer to get around? | Has anyone suggested over the past year that you limit your driving or stop driving | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>   |  |   |  |   |
| Which way do you prefer to get around?   | 1.000                                  | 0.157   | -0.015   | -0.157  |
| Has anyone suggested over the past year that you limit your driving or stop driving  | 0.157                                  | 1.000   | 0.239  | 0.167   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?   | -0.015                                 | 0.239   | 1.000  | 0.096   |
| How would you rate the quality of your driving?  | -0.157                                 | 0.167   | 0.096  | 1.000   |

| <b>Within-Group Correlations</b><br>Group: Sex:Male Age Group:66-70 years Race:White<br>Marked correlations are significant at p < .05000 |  |  |   |
|---|--|--|---|
| Which way do you prefer to get around?  | Has anyone suggested over the past year that you limit your driving or stop driving? | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>  |  |  |   |
| Which way do you prefer to get around?  |  |  |   |
| Has anyone suggested over the past year that you limit your driving or stop driving?  |  |  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?  |  | 1.000  | -0.444  |
| How would you rate the quality of your driving?   |  | -0.444   | 1.000   |

| <b>Within-Group Correlations</b><br>Group: Sex:Male Age Group:71-79 years Race:White<br>Marked correlations are significant at p < .05000 |  |  |   |
|---|--|--|---|
| Which way do you prefer to get around?  | Has anyone suggested over the past year that you limit your driving or stop driving? | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>  |  |  |   |
| Which way do you prefer to get around?  |  |  |   |
| Has anyone suggested over the past year that you limit your driving or stop driving?  |  |  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?  |  | 1.000  | -0.333  |
| How would you rate the quality of your driving?   |  | -0.333   | 1.000   |

| <b>Within-Group Correlations</b><br>Group: Sex:Male Age Group:71-79 years Race:White<br>Marked correlations are significant at p < .05000 |  |  |   |
|---|--|--|---|
| Which way do you prefer to get around?  | Has anyone suggested over the past year that you limit your driving or stop driving? | If you had to go somewhere and didn't want to drive yourself, what would you do? | How would you rate the quality of your driving? |
| <b>Variables</b>  |  |  |   |
| Which way do you prefer to get around?  |  |  |   |
| Has anyone suggested over the past year that you limit your driving or stop driving?  |  |  |   |
| If you had to go somewhere and didn't want to drive yourself, what would you do?  |  | 1.000  | -0.333  |
| How would you rate the quality of your driving?   |  | -0.333   | 1.000   |

## APPENDIX C2: Analysis of Variance (ANOVA)- Driver Habits Questionnaire

| Variable  | Analysis of Variance (Driver Habits Questionnaire) |        |       |         |         |       |       |       |
|---|--|--------|-------|---------|---------|-------|-------|-------|
|   | Marked effects are significant at $p < .05000$     |        |       |         |         |       |       |       |
|   | SS   | df     | MS    | SS      | df      | MS    | F     | p     |
| Which way do you prefer to get around?  | 2.369  | 23.000 | 0.103 | 27.661  | 179.000 | 0.155 | 0.667 | 0.874 |
| Has anyone suggested over the past year that you limit your driving or stop driving | 0.524  | 23.000 | 0.023 | 7.161   | 179.000 | 0.040 | 0.570 | 0.943 |
| If you had to go somewhere and didn't want to drive yourself, what would you do?    | 10.850   | 23.000 | 0.472 | 116.313 | 179.000 | 0.650 | 0.726 | 0.815 |
| How would you rate the quality of your driving?                                     | 4.324  | 23.000 | 0.188 | 46.080  | 179.000 | 0.257 | 0.730 | 0.810 |

APPENDIX C3: Breakdown of Descriptive Statistics

| <b>Breakdown Table of Descriptive Statistics (DHQ- Exposure)</b> |                  |             |  |  |  |   |
|--|------------------|-------------|--|--|--|---|
| <b>Smallest N for any variable: 203</b>                          |                  |             |  |  |  |   |
| <b>Sex</b>   | <b>Age Group</b> | <b>Race</b> | <b>In an average week, how many days do you usually drive?<br/>Means</b> | <b>In an average week, how many days do you usually drive?<br/>N</b> | <b>In an average week, how many days do you usually drive?<br/>Std.Dev</b> | <b>In an average week, how many days do you usually drive?<br/>Variance</b> |
| Female   | 60-65 years      | African     | 5.042  | 24   | 1.967  | 3.868   |
| Female   | 60-65 years      | White       | 4.250  | 4  | 0.957  | 0.917   |
| Female   | 60-65 years      | Coloured    | 7.000  | 1  |  |   |
| Female   | 60-65 years      | Indian      | 5.000  | 1  |  |   |
| Female   | 55-59 years      | African     | 5.967  | 30   | 1.033  | 1.068   |
| Female   | 55-59 years      | White       | 4.909  | 11   | 2.300  | 5.291   |
| Female   | 55-59 years      | Coloured    | 5.000  | 5  | 1.581  | 2.500   |
| Female   | 55-59 years      | Indian      | 5.000  | 1  |  |   |
| Female   | 66-70 years      | African     | 5.000  | 14   | 1.754  | 3.077   |
| Female   | 66-70 years      | White       | 5.333  | 3  | 0.577  | 0.333   |
| Female   | 66-70 years      | Coloured    |  | 0  |  |   |
| Female   | 66-70 years      | Indian      |  | 0  |  |   |
| Female   | 71-79 years      | African     | 7.000  | 2  | 0.000  | 0.000   |
| Female   | 71-79 years      | White       | 5.000  | 1  |  |   |
| Female   | 71-79 years      | Coloured    |  | 0  |  |   |
| Female   | 71-79 years      | Indian      |  | 0  |  |   |
| Male   | 60-65 years      | African     | 5.931  | 29   | 1.361  | 1.852   |
| Male   | 60-65 years      | White       | 6.000  | 4  | 1.414  | 2.000   |
| Male   | 60-65 years      | Coloured    | 4.000  | 1  |  |   |
| Male   | 60-65 years      | Indian      | 5.667  | 3  | 1.155  | 1.333   |
| Male   | 55-59 years      | African     | 5.871  | 31   | 1.565  | 2.449   |
| Male   | 55-59 years      | White       | 6.333  | 6  | 0.516  | 0.267   |
| Male   | 55-59 years      | Coloured    | 4.000  | 1  |  |   |
| Male   | 55-59 years      | Indian      | 6.500  | 2  | 0.707  | 0.500   |
| Male   | 66-70 years      | African     | 5.500  | 14   | 1.653  | 2.731   |
| Male   | 66-70 years      | White       | 5.600  | 10   | 1.075  | 1.156   |
| Male   | 66-70 years      | Coloured    | 5.000  | 1  |  |   |
| Male   | 66-70 years      | Indian      |  | 0  |  |   |
| Male   | 71-79 years      | African     |  | 0  |  |   |
| Male   | 71-79 years      | White       | 6.000  | 4  | 0.816  | 0.667   |
| Male   | 71-79 years      | Coloured    |  | 0  |  |   |
| Male   | 71-79 years      | Indian      |  | 0  |  |   |
| All Groups   |                  |             | 5.586  | 203  | 1.518  | 2.303   |

## APPENDIX C4: Within-Group Correlations (DHQ- Avoidance)

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Female Age Group:60-65 years Race:African</b>      |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     | 1.000  | 0.270  | 0.451  | 0.872   | 0.700  | 0.632  | 0.169  |
| During the past 3 months have you driven alone                   | 0.270  | 1.000  | 0.138  | 0.217   | 0.270  | 0.107  | -0.114   |
| During the past 3 months have you parallel parked?               | 0.451  | 0.138  | 1.000  | 0.574   | 0.451  | 0.519  | 0.589  |
| During the past 3 months, have you driven on highways            | 0.872  | 0.217  | 0.574  | 1.000   | 0.596  | 0.508  | 0.427  |
| During the past 3 months, have you driven on high traffic roads? | 0.700  | 0.270  | 0.451  | 0.596   | 1.000  | 0.632  | 0.169  |
| During the past 3 months, have you driven in rush-hour traffic   | 0.632  | 0.107  | 0.519  | 0.508   | 0.632  | 1.000  | 0.000  |
| During the past 3 months, have you driven at night               | 0.169  | -0.114   | 0.589  | 0.427   | 0.169  | 0.000  | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Female Age Group:60-65 years Race:White</b>        |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     |  |  |  |   |  |  |  |
| During the past 3 months have you driven alone                   |  |  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               |  |  | 1.000  |   | 1.000  | -0.333   | -0.333   |
| During the past 3 months, have you driven on highways            |  |  |  | 1.000   |  |  |  |
| During the past 3 months, have you driven on high traffic roads? |  |  |  | 1.000   | 1.000  | -0.333   | -0.333   |
| During the past 3 months, have you driven in rush-hour traffic   |  |  |  | -0.333  | -0.333   | 1.000  | 1.000  |
| During the past 3 months, have you driven at night               |  |  |  | -0.333  | -0.333   | 1.000  | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Female Age Group:55-59 years Race:African</b>      |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     |  |  |  |   |  |  |  |
| During the past 3 months have you driven alone                   |  |  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               |  |  | 1.000  | -0.071  | 0.356  | 0.200  | -0.120   |
| During the past 3 months, have you driven on highways            |  |  | -0.071   | 1.000   | 0.356  | -0.134   | -0.120   |
| During the past 3 months, have you driven on high traffic roads? |  |  | 0.356  | 0.356   | 1.000  | 0.389  | -0.149   |
| During the past 3 months, have you driven in rush-hour traffic   |  |  | 0.200  | -0.134  | 0.389  | 1.000  | 0.671  |
| During the past 3 months, have you driven at night               |  |  | -0.120   | -0.120  | -0.149   | 0.671  | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Female Age Group:55-59 years Race:White</b>        |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     | 1.000  |  | 0.261  | 0.770   | 1.000  | 0.671  | 0.516  |
| During the past 3 months have you driven alone                   |  |  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               | 0.261  |  | 1.000  | 0.516   | 0.261  | 0.633  | -0.289   |
| During the past 3 months, have you driven on highways            | 0.770  |  | 0.516  | 1.000   | 0.770  | 0.516  | -0.149   |
| During the past 3 months, have you driven on high traffic roads? | 1.000  |  | 0.261  | 0.770   | 1.000  | 0.671  | 0.516  |
| During the past 3 months, have you driven in rush-hour traffic   | 0.671  |  | 0.633  | 0.516   | 0.671  | 1.000  | 0.346  |
| During the past 3 months, have you driven at night               | 0.516  |  | -0.289   | -0.149  | 0.516  | 0.346  | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Female Age Group:55-59 years Race:Coloured</b>     |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     | 1.000  |  |  |   |  |  |  |
| During the past 3 months have you driven alone                   |  | 1.000  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               |  |  | 1.000  |   | -0.250   | 0.612  |  |
| During the past 3 months, have you driven on highways            |  |  |  | 1.000   |  |  |  |
| During the past 3 months, have you driven on high traffic roads? |  |  | -0.250   |   | 1.000  | 0.612  |  |
| During the past 3 months, have you driven in rush-hour traffic   |  |  | 0.612  |   | 0.612  | 1.000  |  |
| During the past 3 months, have you driven at night               |  |  |  |   |  |  | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Female Age Group:66-70 years Race:African</b>      |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     | 1.000  |  |  |   |  |  |  |
| During the past 3 months have you driven alone                   |  | 1.000  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               |  |  | 1.000  |   | -0.145   | -0.145   | -0.145   |
| During the past 3 months, have you driven on highways            |  |  |  | 1.000   |  |  |  |
| During the past 3 months, have you driven on high traffic roads? |  |  | -0.145   |   | 1.000  | 1.000  | -0.077   |
| During the past 3 months, have you driven in rush-hour traffic   |  |  | -0.145   |   | 1.000  | 1.000  | -0.077   |
| During the past 3 months, have you driven at night               |  |  | -0.145   |   | -0.077   | -0.077   | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Male Age Group:60-65 years Race:African</b>        |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     | 1.000  | 1.000  | 0.801  | 0.801   | 0.596  | 0.406  | 0.680  |
| During the past 3 months have you driven alone                   |  | 1.000  | 0.801  | 0.801   | 0.596  | 0.406  | 0.680  |
| During the past 3 months have you parallel parked?               |  | 0.801  | 1.000  | 0.628   | 0.444  | 0.506  | 0.521  |
| During the past 3 months, have you driven on highways            |  | 0.801  | 0.801  | 1.000   | 0.444  | 0.262  | 0.521  |
| During the past 3 months, have you driven on high traffic roads? |  | 0.596  | 0.596  | 0.444   | 1.000  | 0.680  | 0.347  |
| During the past 3 months, have you driven in rush-hour traffic   |  | 0.406  | 0.406  | 0.506   | 0.262  | 1.000  | 0.164  |
| During the past 3 months, have you driven at night               |  | 0.680  | 0.680  | 0.521   | 0.347  | 0.164  | 1.000  |

| <b>Within-Group Correlations</b>                                 |   |  |   |  |  |  |  |
|--|---|--|---|--|--|--|--|
| <b>Group: Sex:Male Age Group:60-65 years Race:White</b>          |   |  |   |  |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |   |  |   |  |  |  |  |
|  | During the past 3 months, have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |  |
| <b>Variables</b>   |   |  |   |  |  |  |  |
| During the past 3 months, have you driven when it's raining?     |   |  |   |  |  |  |  |
| During the past 3 months have you driven alone                   | 1.000   |  |   |  |  |  |  |
| During the past 3 months have you parallel parked?               |   | 1.000  |   | 0.577  | -0.577   |  |  |
| During the past 3 months, have you driven on highways            |   |  | 1.000   |  |  |  |  |
| During the past 3 months, have you driven on high traffic roads? |   |  | 0.577   | 1.000  | -0.333   |  |  |
| During the past 3 months, have you driven in rush-hour traffic   |   |  | -0.577  | -0.333   | 1.000  |  |  |
| During the past 3 months, have you driven at night               |   |  |   |  |  | 1.000  |  |

| <b>Within-Group Correlations</b>                                 |  |  |   |  |  |  |        |
|--|--|--|---|--|--|--|--------|
| <b>Group: Sex:Male Age Group:60-65 years Race:Indian</b>         |  |  |   |  |  |  |        |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |   |  |  |  |        |
|  | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |        |
| <b>Variables</b>   |  |  |   |  |  |  |        |
| During the past 3 months, have you driven when it's raining?     |  |  |   |  |  |  |        |
| During the past 3 months have you driven alone                   |  |  |   |  |  |  |        |
| During the past 3 months have you parallel parked?               |  |  |   |  |  |  |        |
| During the past 3 months, have you driven on highways            |  |  |   |  |  |  |        |
| During the past 3 months, have you driven on high traffic roads? |  |  |   | 1.000  | 1.000  |  | -0.500 |
| During the past 3 months, have you driven in rush-hour traffic   |  |  |   | 1.000  | 1.000  |  | -0.500 |
| During the past 3 months, have you driven at night               |  |  |   | -0.500   | -0.500   |  | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Male Age Group:55-59 years Race:African</b>        |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     | 1.000  | -0.048   | -0.060   | -0.070  | 0.373  | -0.089   | 0.558  |
| During the past 3 months have you driven alone                   | -0.048   | 1.000  | -0.086   | -0.101  | 0.204  | 0.204  | -0.086   |
| During the past 3 months have you parallel parked?               | -0.060   | -0.086   | 1.000  | 0.525   | 0.392  | 0.392  | -0.107   |
| During the past 3 months, have you driven on highways            | -0.070   | -0.101   | 0.525  | 1.000   | 0.299  | 0.299  | 0.199  |
| During the past 3 months, have you driven on high traffic roads? | 0.373  | 0.204  | 0.392  | 0.299   | 1.000  | 0.793  | 0.392  |
| During the past 3 months, have you driven in rush-hour traffic   | -0.089   | 0.204  | 0.392  | 0.299   | 0.793  | 1.000  | 0.116  |
| During the past 3 months, have you driven at night               | 0.558  | -0.086   | -0.107   | 0.199   | 0.392  | 0.116  | 1.000  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Male Age Group:55-59 years Race:Indian</b>         |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     |  |  |  |   |  |  |  |
| During the past 3 months have you driven alone                   |  |  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               |  |  | 1.000  |   | 1.000  |  |  |
| During the past 3 months, have you driven on highways            |  |  |  | 1.000   |  |  |  |
| During the past 3 months, have you driven on high traffic roads? |  |  |  | 1.000   | 1.000  |  |  |
| During the past 3 months, have you driven in rush-hour traffic   |  |  |  |   |  |  |  |

| <b>Within-Group Correlations</b>                                 |  |  |  |   |  |  |  |
|--|--|--|--|---|--|--|--|
| <b>Group: Sex:Male Age Group:66-70 years Race:African</b>        |  |  |  |   |  |  |  |
| <b>Marked correlations are significant at p &lt; .05000</b>      |  |  |  |   |  |  |  |
|  | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
| <b>Variables</b>   |  |  |  |   |  |  |  |
| During the past 3 months, have you driven when it's raining?     | 1.000  |  | 0.531  | 1.000   | 0.531  | 0.439  | -0.077   |
| During the past 3 months have you driven alone                   |  |  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               | 0.531  |  | 1.000  | 0.531   | 0.576  | 0.440  | -0.145   |
| During the past 3 months, have you driven on highways            | 1.000  |  | 0.531  | 1.000   | 0.531  | 0.439  | -0.077   |
| During the past 3 months, have you driven on high traffic roads? | 0.531  |  | 0.576  | 0.531   | 1.000  | 0.826  | -0.145   |
| During the past 3 months, have you driven in rush-hour traffic   | 0.439  |  | 0.440  | 0.439   | 0.826  | 1.000  | -0.175   |
| During the past 3 months, have you driven at night               | -0.077   |  | -0.145   | -0.077  | -0.145   | -0.175   | 1.000  |

**Within-Group Correlations**  
**Group: Sex:Male Age Group:66-70 years Race:White**  
**Marked correlations are significant at  $p < .05000$**

| <b>Variables</b>   | During the past 3 months, have you driven when it's raining? | During the past 3 months have you driven alone | During the past 3 months have you parallel parked? | During the past 3 months, have you driven on highways | During the past 3 months, have you driven on high traffic roads? | During the past 3 months, have you driven in rush-hour traffic | During the past 3 months, have you driven at night |
|--|--|--|--|---|--|--|--|
| During the past 3 months, have you driven when it's raining?     |  |  |  |   |  |  |  |
| During the past 3 months have you driven alone                   |  |  |  |   |  |  |  |
| During the past 3 months have you parallel parked?               |  |  | 1.000  | -0.111  | 0.509  | 0.509  | -0.111   |
| During the past 3 months, have you driven on highways            |  |  | -0.111   | 1.000   | 0.509  | 0.509  | -0.111   |
| During the past 3 months, have you driven on high traffic roads? |  |  | 0.509  | 0.509   | 1.000  | 1.000  | 0.509  |
| During the past 3 months, have you driven in rush-hour traffic   |  |  | 0.509  | 0.509   | 1.000  | 1.000  | 0.509  |
| During the past 3 months, have you driven at night               |  |  | -0.111   | -0.111  | 0.509  | 0.509  | 1.000  |

## Appendix C5: Analysis of Variance (ANOVA) DHQ- Avoidance

| Variable   | Analysis of Variance (DHQ- Avoidance) |        |       |        |         |       |       |       |
|--|---------------------------------------|--------|-------|--------|---------|-------|-------|-------|
|  | SS                                    | df     | MS    | SS     | df      | MS    | F     | p     |
| During the past 3 months, have you driven when it's raining?     | 1.130                                 | 23.000 | 0.049 | 9.274  | 179.000 | 0.052 | 0.949 | 0.534 |
| During the past 3 months have you driven alone                   | 0.256                                 | 23.000 | 0.011 | 5.566  | 179.000 | 0.031 | 0.358 | 0.997 |
| During the past 3 months have you parallel parked?               | 3.340                                 | 23.000 | 0.145 | 23.616 | 179.000 | 0.132 | 1.101 | 0.348 |
| During the past 3 months, have you driven on highways            | 0.940                                 | 23.000 | 0.041 | 15.463 | 179.000 | 0.086 | 0.473 | 0.981 |
| During the past 3 months, have you driven on high traffic roads? | 2.261                                 | 23.000 | 0.098 | 26.044 | 179.000 | 0.145 | 0.676 | 0.865 |
| During the past 3 months, have you driven I rush-hour traffic    | 4.526                                 | 23.000 | 0.197 | 33.159 | 179.000 | 0.185 | 1.062 | 0.392 |
| During the past 3 months, have you driven at night               | 1.583                                 | 23.000 | 0.069 | 18.033 | 179.000 | 0.101 | 0.683 | 0.858 |