DO DIFFERENCES IN PERSONALITY TRAITS AFFECT HOW DRIVERS EXPERIENCE MUSIC AT DIFFERENT INTENSITIES?

BY

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THESIS

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ABSTRACT

Various researchers have investigated contributing factors towards the number of acute traffic incidences in and around Southern Africa. Some of these contributing factors include: the skills component of the driver predominately attributed to driving experience as well as the behavioural component influenced by the driver's natural predisposition, individual differences and personality traits. In order to manage these factors drivers have developed varying coping mechanisms. One of these coping mechanisms is listening to music while driving, which is readily available in most cars and extensively used predominately during long duration driving. Listening to music neither increases one's driving duration (as opposed to taking several breaks), nor does it interfere with the physical movements of driving (in the manner that eating and drinking may), but it might impact the concentration and attention of some drivers. This is based on the notion that music is assumed to impact arousal and cognitive ability. While there are several studies on the effect of music on driving performance and personality traits very few studies have looked at whether music has a positive or negative effect on driving performance based on differences in personality traits; and whether the extent of this effect might differ for different intensities of music? Consequently, this study aims to understand and determine the extent to which different personality traits predict the effect that listening to different music intensities has on driving performance.

The impact of differing music conditions on the different personality traits used a repeated measures design and a between group design with respect to the personality traits with a sample size of (n=25)-16 females and 9 males-and their ages ranged between 19-35 years of age. The average age and standard deviation for this sample size was 22 years±2. A low-fidelity driving simulator task was utilised in order to provide a controllable, repeatable and a safe environment as compared to a real road situation. Personality was assessed using an online Big-Five Inventory scale (extraversion, agreeableness, conscientiousness, neuroticism, openness). All the different personality groups completed three conditions (45 minutes each) in a randomised order (without music, moderately loud music and loud music). Psychophysiological parameters i.e. heart rate frequency (HRF), heart rate variability

(HRV) and eye movements (pupil diameter, eye speeds, fixation duration, blink frequency and blink duration) and driving performance were measured continuously. Subjective performance Multidimensional Driving Style Inventory was measured once-off prior to completion of the testing sessions, whilst the NASA-Task Load Index scale and Perceived control of participants were assessed after each condition.

The expected outcomes revealed that music had an effect on objective driving performance (tracking deviation and reaction time) and psychophysiological measures only for participants of certain personality types while other personality types were unaffected by music. The subjective performance measures did not follow the same trend as objective performance measures. The conditions did not reveal an effect on driving performance, for most of the psychophysiological parameters and subjective measures. There was mainly a significant time on task effect and interactional effects on the psychophysiological measures (physiological and oculomotor) parameters at ($p<0.05$), but not on the subjective measures as anticipated.

The study illustrated that the there are differences between personality traits. There was difficulty in the interpretation of the results based on the complexity of the findings for which each hypothesis was partially accepted. The research may establish practical implications for traffic safety campaigns in South Africa, as well as influence driving education for citizens. Assessing the personality trait would help to form an understanding as to which of the personality traits might be affected negatively from listening to music while driving and those that might benefit. Moreover, this study may assist motorists in understanding the implications of listening to music while driving as this may sometimes elicit risky driving behaviour and possibly cause an accident that may result in death.

Key words: Emotional-related distractions, emotional-related auditory distraction, music, driving performance, personality traits, sad music, happy music, neutral music, individual difference, music preferences.

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CHAPTER I

1. INTRODUCTION

1.1 ROAD ACCIDENT CONTEXT IN SOUTH AFRICA

The commonality of driving an automobile has resulted in a 23.7% increase in the number of licensed road users since 1990-2010 (Louw, 2013). Driving an automobile is a necessary luxury for citizens giving them autonomy of freedom, while the motor industry boosts the economic development of the country. However, due to the influx of licensed drivers, high traffic volumes and other factors, the number of road accidents in South Africa and the world over is disproportionately high, despite the increased effort to improve vehicle design, safety of the roads and educating civilians on defensive driving (Kopits and Cropper, 2005; Louw, 2013). Road accidents not only impact on South African societies regarding the tragedy, human loss and suffering, it also has an effect on the socio-economic cost to the country's Gross Domestic Product (Yannis *et al*., 2014). Consequently, the accidents in South Africa are a cause for concern. Thus, there is a need to investigate various driving factors in order to alleviate dangers associated with driving (De Beer *et al*., 2002).

De Beer *et al*. (2002) state that the accident unit cost figures are based on the 'human capital' approach or the 'gross output' method which is suitable for developing countries such as South Africa (De Deer *et al*., 2002). For example, the capital and gross output methods include and account for the direct costs: hospital, medical and funeral costs, vehicle damage costs, damage to goods, legal costs, damage to fixed property, insurance administrative costs, towing costs, policing and promotion costs, the loss of output and lastly the qualitative costs such as pain and suffering and loss of life (De Beer *et al*., 2002).

The research findings by De Beer *et al*. (2002) suggest that a more advanced and efficient method must incorporate urban versus rural areas, the severity of the accidents, type of the vehicle, as well as the age group of the victims, person costs, vehicle damage, incidents costs, legal and administrative costs in order to establish a more holistic approach regarding the total cost of traffic accidents (De Beer *et al*., 2002). The total cost of injuries as a result of accidents amounted to nearly R23.8 billion for both urban and rural areas in 2002 and continues to rise to an estimated R306 billion in 2012 (De Beer *et al*., 2002; Louw 2013). A plethora of evidence suggests that driving safety remains an imperative issue in South Africa and the rest of the world; as has been confirmed by several macroscopic studies since the 1960s (Yannis *et al*., 2014). The intention of the study looks towards assisting in reducing a potential causation to traffic fatalities which may benefit the society of South Africa as well reduce the social cost impacting the Gross Domestic Product (Yamakoshi *et al.*, 2009)

1.2 BACKGROUND OF THE STUDY

Driving is considered a common activity that requires the involvement of a human's cognitive, physical, sensory and psychomotor skills, all coordinating in unison to establish the desired outcome, in this case reaching one's destination (Horberry *et al.*, 2006; Choi *et al*., 2013; Hughes *et al*., 2013; Jackson *et al*., 2013). For this reason driving an automobile is considered a complex task as it comprises two distinct components namely: a skills component, that is dependent on the experience of the driver, and the behavioural component, that is affected by the age of the driver, personality traits of the individual as well as environmental factors (weather conditions, road conditions and traffic) (Choi *et al.*, 2013; Hughes *et al.,* 2013; Gastaldi *et al*., 2014). Owing to the aforementioned factors that make driving complex, road traffic accidents are often grouped into a closed loop system that is composed of the human, the vehicle and environmental factors (Ndaki, 2012; Chen *et al*., 2013; Louw, 2013). Therefore this study looks towards humans and the vehicle with regards to the coping behaviour or 'mechanism' most motorists are prone to using which is listening to music while driving.

Motorists engage in varying degrees of primary and secondary activities while driving; some of which may create an imbalance in the cognitive, physical, sensory, psychomotor skills (this may include the skills and behavioural components). The imbalance of the above mentioned factors contribute to road traffic accidents reported annually in and around South Africa (Reimer *et al*., 2010; Louw, 2013).

These primary and secondary activities are best described as driver distractions. Whilst not all primary and secondary activities affect driving, a vast number of these distractions are either external or internal in nature and contribute towards visual and cognitive deviations that ultimately lead towards traffic related incidents or accidents (Reimer *et al*., 2010; Choi *et al.*, 2013; Chan and Singhal, 2015). For purposes of this study, driver distractions refer to the "triggering of an event or activity as opposed to inattention due to a cognitive state" (Chan and Singhal, 2015, p. 302). On the one hand there is a multitude of external distractions such as road signs, billboards, pedestrians, road works, and vendors that may distract drivers leading up to driver errors and incidents (Choi *et al.*, 2013). In contrast, internal distractions refer to the interaction with passengers, using the cell phone while driving, operating of in-vehicle information systems such as a Global Positioning Systems (GPS) or the controls of an entertainment system, such as the radio (Brodsky, 2001; Brooks and Rakotonirainy, 2005; Reimer *et al*. 2010; Mitsopoulos-Rubens *et al*., 2011; Hughes *et al.*, 2013; Chan and Singhal, 2015).

Research findings therefore suggest that drivers tend to adhere to different behaviours in the hope of alleviating external and internal factors concerning the driver so as to maintain alertness (Brodsky, 2001; Oron-Gilad *et al*., 2008). These behaviours include the opening of car windows for air, drinking coffee and/or energy drinks before and during the trip, following lane markers, talking to pedestrians and the most common-listening to music while driving (Oron-Gilad *et al*., 2008).

Drivers therefore, may find themselves taking part in more than one behaviour mentioned above; however, the study detaches the other behaviours, focusing solely on the act of listening to music while driving as a coping mechanism. So, with regards to the establishment of music in vehicles, Brodsky (2001) states that radios in a vehicle were made available since the early 1930s, and therefore listening to music has been deemed as one of the most common secondary activities seen in transportation (Brodsky, 2001). More specifically, the radio in the vehicle may not only have been used to provide information, but also as a source of entertainment alleviating monotony, boredom and/or fatigue associated with long-distance driving (Brodsky, 2001). Interestingly so, despite the availability of this feature in most if not all vehicles, not all motorists make use of this feature while driving. Hughes *et al*.

(2013) study found that an average of 68% of motorists claimed to listen to music while driving, implying that an average of 32% of the motorists do not listen to music while driving. While it was not documented the assumption is that the 32% of the participants that do not listen to music, may not need the music to cope with the long-distance drive, as they may find the manipulating controls to select a song, the sound intensity of the song, and the auditory stimuli experienced as a distracting component tha may affect concentration and thus cognitive performance (Mitsopoulos-Rubens *et al*., 2006; Hughes *et al*., 2013). According to Reimer *et al*. (2010, p. 842) the duration of cognitive distraction is often longer than that of visual distractions, as with cognitive distractions "an operators eyes may be directed toward the road, but the focus of attention may be else-where." Moreover in-vehicle music may mask auditory feedback from environmental noise produced by other vehicles, suggesting that the dual operation of listening to environmental noise coupled with in-vehicle noise may possibly reduce alertness, concentration and cognitive performance thereby reducing driving performance (Mitsopoulos-Rubens *et al.*, 2006; Hughes *et al.*, 2013).

Furthermore, research findings express that in-car listening may be an auditory distracter due to the type of music (emotional auditory content) listened to (Chan and Singhal, 2015). Various researchers have suggested that 'happy' music distracts drivers and results in poor lane-keeping ability compared to a 'no music condition' or neutral beep sounds (Pêcher *et al*., 2009; Hughes *et al*., 2013). In addition, listening to music when driving increased the motorists' driving speeds and this was dependent on a number of music characteristics such as the tempo, genre and sound intensity of the music (Hughes *et al.*, 2013). The 'happy' music propelled participants to sing along, whistle, tap and dance to the music reducing adequate vehicular control (Hughes *et al*., 2013), whereas 'sad' music slightly reduced speeds, but improved lane-keeping ability (Hughes *et al.*, 2013). However, according to Chan and Singhal (2015) and Pêcher *et al*. (2009) positive sounds or music reduced driving speeds and impaired lateral control more than sad songs and neutral music. Auditory stimuli with emotional lyrical content, may modulate attention to influence driving performance for different personality traits (Nieminen *et al*., 2011; Chan and Singhal, 2015).

Despite the above-mentioned notions, literature indicates positive and detrimental effects on the motorists' driving performance when listening to music and driving (Pêcher *et al*., 2009; Hughes *et al*., 2013; Chan and Singhal, 2015). These are dependent on several factors, most of which have been attributed to the genetic predisposition, basic demographics and certain personality traits, which have long been cited as the central cause of risky driving and traffic incidences (Taubman-Ben-Ari and Yehiel, 2012). Individuals often have a preference for different music characteristics i.e. music type, tempos, genre and sound intensity and this may elicit certain behaviours (Hughes *et al*., 2013, Adrian *et al.* 2011; Classen *et al.,* 2011). Individuals respond differently to the music characteristics; this may explain the inconclusive results obtained on investigating the impact of listening to music on driving performance. As a result of the contradictory findings regarding the impact of audition as a distracter to drivers, this study aims to investigate the behavioural and skills component of listening to music while driving and how each personality trait (extraversion, agreeableness, conscientiousness, neuroticism and openness) may respond differently under different music conditions at different intensities or loudness. It will further establish findings by investigating the psychophysiological and subjective measures of the research question.

1.3 STATEMENT OF THE PROBLEM

The study aims to corroborate and determine the extent to which different personality traits predicts the degree to which an auditory stimulus in the form of music has on driving performance, most appropriately under a driving condition. The research may establish practical implications for traffic safety campaigns as well as influence driving education for all citizens, individuals working in logistics and other transportation mediums. Assessing the personality traits might help establish which personality traits benefit most from listening to music while driving and which ones have the most negative effect.

THESIS OBJECTIVES:

1. Provide analysis of driving performance in a simulated driving task from a psychophysiological measure, personality trait, and subjective measure perspective.
2. Assess the interactional effect between the personality traits of participants under the driving conditions.
3. Provide an in-depth analysis of auditory distractions in driving performance.
4. To investigate whether different music intensities affect different personality traits while driving.

By achieving these objectives this research hopes to provide greater insight regarding distractions that contribute to driving error and therefore traffic fatalities and injuries.

CHAPTER II
2. REVIEW OF LITERATURE

INTRODUCTION

This chapter aims to discuss and support various theories and concepts in relation to the study performed. The chapter gives a brief overview, in section 2.1. It discusses literature related to driving in the context of South Africa 2.2. In section 2.3 theories related to concepts under the umbrella of driving research such as information processing and attentional resources of human beings, address the concepts of driving performance such as external and internal factors, distractions and drivers' characteristics that may affect driving ability. Section 2.4 introduces the role music plays in the context of this study and finally section 2.5 addresses the personality traits and the personality traits in the context of driving.

OVERVIEW

Ergonomics takes into account the designing of systems and processes, products, machines and investigates the efficiency of people in their working environments (Cai and Lin, 2011). Driving research explores the interface between the vehicle and human; making an allowance for biomechanical, cognitive, behavioural and physical challenges a motorist might experience under varying environments and circumstances (Ting *et al*., 2008; Cai and Lin, 2011). The complexity of a driving task is often dictated by the motorist's overall cognitive effort, visual-spatial ability, memory, information processing, rapid reaction**,** vigilance and physical factors which are also subject to the motorists' skills and behavioural *components* (Ting *et al*., 2008; Cassavaugh and Kramer, 2009; Cai and Lin, 2011). The potential for an auditory modality (the ability to hear) at different intensities to alter one's attention and information processing ability is relatively unknown for the varying dominant personality traits. Auditory stimuli may be a potential distracter for certain drivers, as the attention and information processing of human beings may amend itself due to the music's emotional lyrical content and/or instrumental composition, that influences emotional responses and behaviour (Brodsky, 2001; Cai and Lin, 2011). The notion in changes of emotional responses due to the music's lyrical content is further substantiated by Cai and Lin (2011) who have explained that emotional driving behaviours often lead to severe traffic accidents as a direct result of prolonged reaction times and impaired cognitive skills. Whilst *emotional distractions* by music do not form the main part of this study it is worth mentioning that this phenomenon may play a role in the distraction of drivers and therefore on overall performance (Cai and Lin, 2011).

2.1 DRIVING IN THE CONTEXT OF SA

The data on road traffic accidents, injuries and incidences is collected, gathered, analysed and stored by a variety of agencies which include the Road Transport Management Corporation (RTMC), National Mortality Surveillance System (NIMSS) and Statistics South Africa (Stats SA) (Statistics South Africa, 2009). Each organisation or agency is involved in different aspects of the collecting of data, RTMC gathers and analyses data on the road traffic injuries and fatalities through accident report forms which are completed by the South African Police Services (Statistics South Africa, 2009). The NIMSS is a project that makes part of the Medical Research Council/ University of South Africa (UNISA) which provides information on non-natural form of death with include violent crimes, and road traffic deaths from selected mortuaries. Stats SA gathers information via the country's death notification system from the National Department of Home Affairs. In this regard therefore, the information gives an account of the trends in non-natural deaths that occur in the country, more specifically in the context of road traffic accidents.

Stats SA highlights in the main executive summary road traffic accidents from 2001-2006. The findings were documented as follows:

- Land transport contributed the highest proportion (99.8%) of the total transport accident deaths in SA as compared to water and air transport.
- Nearly 83.4% deaths have been as a result of road transport accidents and the deaths occurred in the province of usual residence.
- The highest accident rates occurred in December and were the lowest between January and February.

- ‘Crude road traffic accidents death rates varied slightly from 9.9 per 10 000 population in 2001 to 11.8 per 100000 in 2006. Standardised death rates indicate that differences over the years are due to factors other than changes in population age composition.’
- Road traffic accidents were highest amongst the age group 35-49, and were lowest between ages 0-14 and 15-24.
- The death rate in males was more than two and half times that for females.
- Limpopo province had the highest death rate whilst Gauteng had the lowest death rate.

Stats SA documents that injury and mortality in road collisions are a public health problem with consequences similar to those of major non-communicable diseases such as cardiovascular diseases and cancer (Statistics South Africa, 2009). The road traffic injuries was the 11th leading cause of death worldwide and accounted for 2.11 % of all accidents globally. The majority of the road traffic deaths occur in low-middle income countries, at an overwhelming 90%. Statistics South Africa estimates that the global overall increase in road traffic accident mortality is predicted to be 67% by 2020 if measures aren’t taken to rectify the increase of accidents.

Table I: The distribution of road traffic accidents by the type of transport mode and the year of accidents (adapted from Statistics South Africa, 2009, p. 12).

Year	**Land transport/road traffic accident**	**Water transport**	**Air and space transport**	**Other and unspecified transport accidents**	**Total**
2001	4433	2	12	2	**4449**
2002	3661	0	1	1	**3663**
2003	4455	0	6	7	**4468**
2004	5234	2	3	3	**5242**
2005	5443	0	5	6	**5454**
2006	5664	0	4	1	**5696**
Total	**28 890**	**4**	**31**	**20**	**28 945**

Table I above provides information on the number of accidents that occurred in South Africa from 2001 to 2006, showing a steady increase each year. The land transport/road traffic accidents illustrate as being the main contributing factor of total accidents as compared to water, air and space and other unspecified forms of transportation (Statistics South Africa, 2009). The findings continue to show fluctuations and increase of road traffic accidents. In order to reduce the continuous toll, it would require a deep understanding and investigation into all factors and facets contributiong to road accidents (Louw, 2013).

2.2 THEORECTICAL CONCEPTS OF DRIVING RESEARCH

Information Processing:

The human information processing model forms part of the attentional resource theory and the stages within the information processing model indicate that attention resources acts somewhat as a 'plug point' to which the perception, thought decision making, working memory, response selection and response execution will enable the ability for one to transform and encode information received as well as to give the appropriate response. Essentially, Wickens' (1984) model on human information processing posits the succession towards which information is processed, stored and other times remembered (Louw, 2013). The stages are named as follows: *sensory memory*, *perception, thought decision making, working memory, long term memory, response selection* and lastly the *response execution*. Without a certain level of attention or effort required there is a chance of one experiencing a break down with regards to the thought process, decision making, encoding and transformation and dissemination of the information, as the lapse in attention creates the possible driving errors (Lee, 2008; Vaportzis *et al*., 2013). Therefore, central processing of information however, can only occur with the ability for one to receive the information from the external environment through sensory memory, in the form of visual, and/or auditory modalities, as well as proprioceptive or kinaesthetic senses of the body (touch, taste, smell, position, and motion) (Wickens, 1984; Louw, 2013; Huysamen, 2014). For example, the execution of a driving task is a combination of different variables that requires the use of visual stimuli; once a motorist has seen the objects ahead, the driver may interpret, process and translate information most accurately requiring the use of mental concentration, attention and skills, which emphasises the complexity associated to driving (Horberry *et al*., 2006; Anderson *et al*., 2011; Choi *et al*., 2013; Jackson *et al*., 2013).

The sensation therefore is transferred to the perception stage when the brain identifies and deciphers the stimuli so that it may further be transferred to the necessary stage. The central processing requires cognitive capability, attention, and mental effort to both extract and extrapolate information that is received through the sensory memory that may have been stored in the long term memory through past experience, knowledge, emotion, and feelings (Wickens, 1984; Huysamen, 2014). The cognitive capability also allows for the information to undergo thought or decision making ability; for example, in the case of driving, a motorist would have to think and decide whether or not to turn left or right when approaching a yield sign, or in other instances decide on appropriate manoeuvre when avoiding a collision (Pearman, 2009). Related to this, many studies have demonstrated how personality traits and sex differences may impact on the basic cognitive functioning (processing speed and short term memory) (Pearman, 2009). Eventually the choice of various manoeuvres to be completed has gone through the appropriate stage of response selection and later response execution- for instance, applying the brakes of the car, turning the steering wheel, indicating and so on-all part of the process where the brain has communicated with the muscles of the body for the best response (Pearman, 2009).

To reiterate, driving performance is made possible by a combination of contributing domains (microscopic and macroscopic), namely: perceptual, cognitive, motor control, and driving knowledge; simultaneously driving performance is affected by several other factors (Gray *et al*., 2002; Treffner *et al*., 2002; Stav *et al*., 2008). These factors include but are not limited to the experience of drivers, the effects of distractions and driver error, personality traits, sex differences, age-related changes in cognitive ability and therefore driving performance, a driver's behavioural component such as drinking alcohol when driving, traffic density when exiting a freeway and so on (Ginsburg *et al*., 2008; Young *et al*., 2008; Pearman, 2009; Calvi *et al*., 2012; Sinclair, 2013; Young *et al*., 2013).

Therefore, it should be recognised that the processing of information at each stage takes time and may be lengthened due to the factors mentioned previously as well as the concepts discussed such as monotony of task and boredom associated with it, fatigue, overload of the information and possible ambiguity and/or confusion surrounding the relevant information (Wickens, 1992; Huyseman, 2014). Moreover prolonged information processing in humans is due to distractions and individual differences in the ability to process information. Wickens' Human Information Processing Model (Figure 1) is described above and follows hereunder.

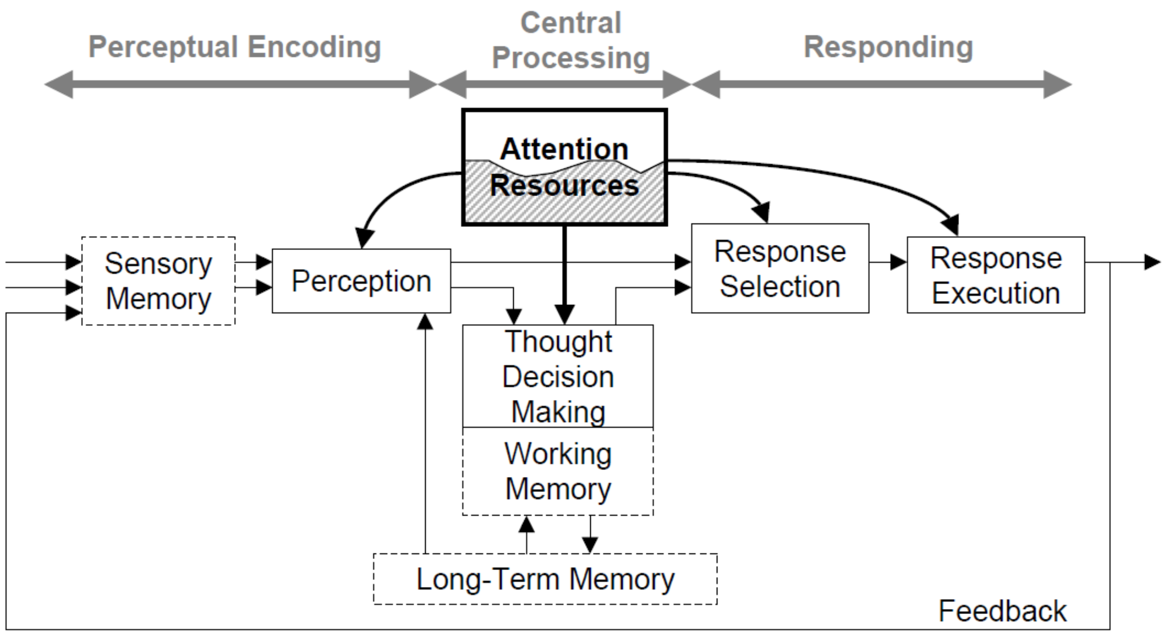

Figure 1: Model of the human information processing system (from Wicken's, 1984, p.12).

Attentional Resources:

The attention of the driver is thus paramount in overcoming either the external or internal factors that contribute to the deterioration in driving (Choi *et al*., 2013; Chan *et al*., 2015). According to Choi *et al*. (2013, p. 538) attention is considered as "the smooth processing of information, which goes through various cognitive steps in order for the driver to select information suitable for the goals and demands in the surrounding environment". A disruption in this cognitive process may possibly impede driving ability, which is unfavourable and dangerous for the driver and other road users (Choi *et al*., 2013). The concept of attention is greatly accredited in driving safety research as attention is considered a fundamental principle in the ability for one to execute appropriate driving manoeuvres with minimal risk (Choi *et al.*, 2013). Therefore, listening to music may either impede the cognitive process related to attention or enhance it depending on the driver's personality assembly (Reimer *et al*., 2010; Hughes *et al*., 2013; Ünal *et al*., 2013). The nature of personality in the context of driving is linked and attributed to the music one listens to while driving, perhaps inducing the psychological, cognitive and emotional state of an individual, while performing a simulated driving task (Adrian *et al*., 2011). It has been shown that listening to music while executing driving tasks may evoke psychological, cognitive and emotional entities that may remove from an individual's attention resources (Adrian *et al*., 2011; Choi *et al.*, 2013).

Early research conducted by Kahneman (1973) established the principle of the attentional resources or capacity concept, which assumes that each individual has a fixed or limited attentional resource capacity (Wickens, 1984). This capacity model on attention can also be described as a reservoir of mental resources or general resource pool and was an alternative theory to the bottleneck or filter theory (Wickens, 2002; Young and Stanton, 2002a; Staal, 2004; Gershon *et al*., 2009; De Gray Birch, 2012). The theory therefore posits that deterioration of performance is as a result of task attentional demands exceeding that of the resource capacity (Wickens, 1984; Gershon *et al*., 2009), of which in this context listening to music while driving may exceed the attention required to facilitate a driving task. In addition, the work of Kahneman (1973) proposed that the capacity limit was susceptible to change due to factors such as age, mood and arousal (Young and Stanton, 2002a). So, adequately accomplishing any given task would require the efficient allocation of attention to each task that is being performed (Young and Stanton, 2002a). However, if the demands of the task exceeded the capacity limit, this would cause a disturbance and interference in attention resulting in a weakened performance outcome (Young and Stanton, 2002a).

The malleable attention theory is an intermediate stage in the theory development between attentional resource and multiple resource theory and this theory reflects the attitude that the resource pools are not fixed and can change depending on the task demands in a short term (Young and Stanton, 2002b). That is to say that a decrease in performance due to underload conditions or the reduction in task demand will result in the shrinkage of the available reservoir as opposed the fixed or limited attentional resource capacity (Young and Stanton, 2002b; Gershon *et al*., 2009). Thus, in the context of listening to music it is not necessarily considered an underload condition, and yet it may have the potential to diminish or reduce the attentional reservoir as it is person specific (Wickens, 2002). The proposed notion therefore takes on the concept of the multiple resource theory that follows the initial resource theory proposed by the work of Wickens (2002). Wickens (2002) demonstrated the flaws in the theoretical framework associated with the attentional resource capacity model, and it argued against the notion that attention operates on a single resource while one is performing many tasks concurrently and therefore the multiple resource theory argues that there are many attentional resources that are required and used in different situations. Therefore, listening to music draws on one attentional resource, and driving draws on another, thus making the multiple resource theory more applicable in this context (Wickens, 2002). Regardless of this fact, however, both theories assume the weakening of a performance is due to the depletion of the attention resources (Louw, 2013).

Wickens (2002) mentions that the multiple resource theory can be defined according to four dimensions, which can be associated with distinct physiological mechanisms. The first of these dimensions is the processing stage which refers to towards the use of different resources pertaining to the perceptual and cognitive tasks, different from that required for selection and action purposes. Following this, is the processing code which takes into account the spatial, verbal and linguistic activity, which also requires the use of different resources in order to code the information received initially. The third of the dimensions is known as the perceptual modalities; these modalities refer to the visual and auditory perceptions through which information is received and later interpreted. Last of these dimensions is the visual channels known as the ambient and focal vision (Wickens, 2002). According to Ohno (1991) the two visual channels differ in their functions, but however interact with one another to achieve perceptual synthesis of events. Ohno (1991) documents that ambient and focal vision are considered as pre-attentive and attentive visual systems respectively.

The differences of these channels are summarised in Table II. Therefore, tasks required in driving may draw on all these multiple resources, and if any of the resources are lessened or if they overlap, it may hamper the driving performance in its entirety.

Table II: Differences in Focal and Ambient visual channels forming part of the dimensions required in the multiple resource theory (adapted from Ohno, 1991, p. 238).

	Ambient vision	**Focal vision**
Source of information	Continuous environmental features (surfaces)	Discrete elements
Perceiver's attitude	Scattered attention unconscious/subliminal	Focal attention conscious/ attentional
Nature of information processing	Perceptual integration limited information per element instant process	Perceptual selection detailed information per element
Outcome functions	Global impression/feeling body locomotion attention evocation orientation.	Understanding detection/recognition of objects

Arousal and Activation theory:

Seminal work which was conducted by Easterbrook (1959) explains the link between arousal and attention through the cue-utilization theory (Ünal *et al*., 2013). This theory claims that both under-arousal and over-arousal would have negative consequences on attention and impair the necessary cues in order to perform a task effectively and efficiently (Pattyn *et al*., 2008; Ünal *et al*., 2013). Inattention of an individual often suggests a reduction in arousal, which is related to the level of stimulation experienced by an individual and also produces vigilance decrements particularly for vigilance tasks which driving forms part of. For purposes of this study arousal is defined as the "level of activation of the central nervous system, and varies from extremely low level states, such as sleeping to high levels of activation seen during physical activity or mentally demanding activities" (Schmidt and Wrisberg, 2008, p. 39).

The cue-utilization theory is further substantiated as the inverted U-principle which says that a moderate level of arousal is possibly considered as the most desirable optimum level, which may result in the better performance of a task; in this case, driving ability (Schmidt and Wrisberg, 2008; Ünal *et al*., 2013). This theory, however highlights the discrepancy observed regarding the use of listening to music while driving as a coping mechanism for overcoming boredom, monotony and fatigue, as listening to music at different intensities is individual specific and may induce arousal affecting performance efficiency of the driver (Schmidt and Wrisberg, 2008). Furthermore Schmidt and Wrisberg (2008) state that the level of arousal is also task specific. Tasks that require fine muscular control need a lower level of arousal, whilst tasks that require the use of large muscle groups like the participation in sports, may require higher levels of arousal (Schmidt and Wrisberg, 2008). Figure 2 illustrates the inverted U-principle model of arousal.

The explanation of the inverted U-principle is one that is however not unilateral in nature, seeing that humans tend to adapt compensatory methods to regulate a low or high arousal state (Schmidt and Wrisberg, 2008). This is due to the fact that the various functions of the human system are complex in nature, with each interacting with other systems of the body; therefore, different stressors will produce differences in perceptual, psychophysiological functioning and may require additional effort in order to complete the task regardless of the stress applied (De Gray Birch, 2012).

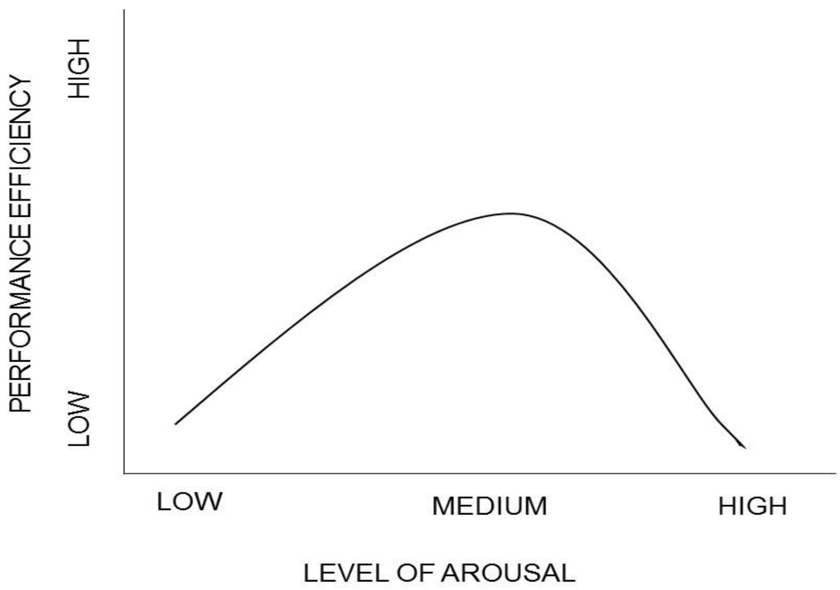

Figure 2: Adapted model of the inverted U-Principle, illustrating performance efficiency as a function of the level of arousal (Schmidt and Wrisberg, 2008).

Effort Regulation:

The effort-regulation espouses that inadequate executive allocation of the attentional resources will lead to a performance decrement (Matthews and Desmond, 2002). The lapse in concentration may be attributed to intuitive failures of attention; namely selective attention, focused attention and divided attention (Wickens and Holland, 2000). Selective attention refers to the process of one selecting inappropriate aspects of the environment to process- it is particularly intentional and it is considered unwise to select (Wickens and Holland, 2000). Focused attention refers to the inability for one to sustain concentration on one's source of information in spite of the desire to do so (Wickens and Holland, 2000). Lastly there is the divided attention, which occurs as a malfunction of the focused attention, where attention is "inadvertently directed to a stimuli or event that one does not wish to process" (Wickens and Holland, 2000, p. 70). Moreover, Wickens and Holland (2000) assert that divided attention describes sometimes our limited inability to time-share performance of two or more concurrent tasks. This seems more likely in the case of listening to music while driving as depending on various features of a song, may cause one to misallocate attentional resources to a time, memory, and emotion attached to the song making one lapse in concentration for a moment (Wickens and

Holland, 2000). Furthermore listening to music while driving may create a lapse in concentration better referred to as divided attention for different personality types. Therefore, a conscious effort might be required to overcome this discrepancy. Effort is said to be directly responsible for conscious processing, or computational control of decision making processes (De Gray Birch, 2012). According to De Gray Birch (2012), the effort-regulation theory focuses more on an individual's threshold to put in the required effort to accomplish a task, as opposed to the resource availability.

Effort is often demonstrated in the context of fatigue, such that empirical studies have demonstrated mental effort (task effort and state effort) to be necessary in overcoming or counteracting fatigue experienced particularly with a monotonous drive (Matthews and Desmond, 2002; Oron-Gilad and Hancock, 2005; De Gray Birch, 2012). Yet effort may be required in order to overcome the cognitive state of maintaining control of the vehicle while listening to a tune, as listening to music is a readily available source used as a coping mechanism to overcome fatigue (Brodsky, 2001). This kind of situation may increase the mental effort required to deal with the fatigue experienced as well as to handle the noise heard internally against environmental noise and the natural physiological state to experience drowsiness, sleepiness, and fatigue regardless of the music played. Therefore, effort can be described in the context of mobilising extra resources for challenging tasks or it can be used as an invested, concentrated attempt of counteracting internal factors experienced during monotonous situations, as the regulation of effort can be conscious and subconscious form as it depends on the task (De Gray Birch, 2012).

2.3 CONCEPTS OF DRIVING PERFORMANCE

2.3.1 Performance shaping factors

Performance shaping factors of driving ability is therefore affected by external and internal factors. In the following section each of these factors will be discussed in detail. In the driving research world external factors are attributed to those factors that are peripheral to the driver. External factors are often attributed to the things the driver cannot control, such as technology of the vehicle and/or environmental conditions. Conversely, internal factors denote the influences that affect the driver directly and are internal to the vehicle. For example, motorists experience the environment differently and this often intensifies underlining issues that further influence the driving experience such as the monotony of a long distance drive or otherwise, boredom, fatigue, and attentional resources (Regan *et al*., 2011).

External Factors

Technology:

Improved vehicle design and vehicle-operating characteristics have been one focal points in improving the safety and efficient design of vehicles suitable for the driver (Calvi *et al*., 2012). Safety however, from the early stages of automobile production was not necessarily a leading factor, particularly during the 1800's (Akamatsu *et al*., 2013). The introduction and evolution of human factors began predominately during the 1940-1949 (Akamatsu *et al*., 2013). The first account of human factors research resulted in the adaptation of military technologies to human operators that aimed to improve the safety and make systems more reliable. This then trickled into the aviation and automotive industries after the World War II (Akamatsu *et al*., 2013). A concept called Passive Safety technology, thus took form and this very method is still utilised currently within the automotive industry. The seat belt was the evidence of the use of the passive safety technology, which was installed by Nash Motors in 1949 (Akamatsu *et al*., 2013). A succession of events thus occurred thereafter resulting in the collection of anthropometric data in the 1950's, crash assessments and occupant comfort testing in the 1970's (Akamatsu *et al*., 2013). The use of eye tracking devices and simulators was also introduced in the 1970's (Akamatsu *et al*., 2013). As a result the reinforcement of safety mechanisms in vehicles remains an important part in vehicular design, as the safety mechanisms of the cars are typically used to prevent the unnecessary usage of the system, and to caution drivers to potential malfunction of the vehicle (Cherfi *et al*., 2014). However, despite increased efforts in vehicular design and usage of safety mechanisms, the increase in traffic incidences still remains life threatening. For example, as a result of the higher speed and power ability of the vehicles, drivers tend to employ riskier driving behaviours. At the same time faulty brake systems, tyre bursts, navigation and GPS systems can also impact on the overall driving experience. Chen *et al*. (2013) details the concept of safety in vehicles that can be divided into active safety and passive safety technology.

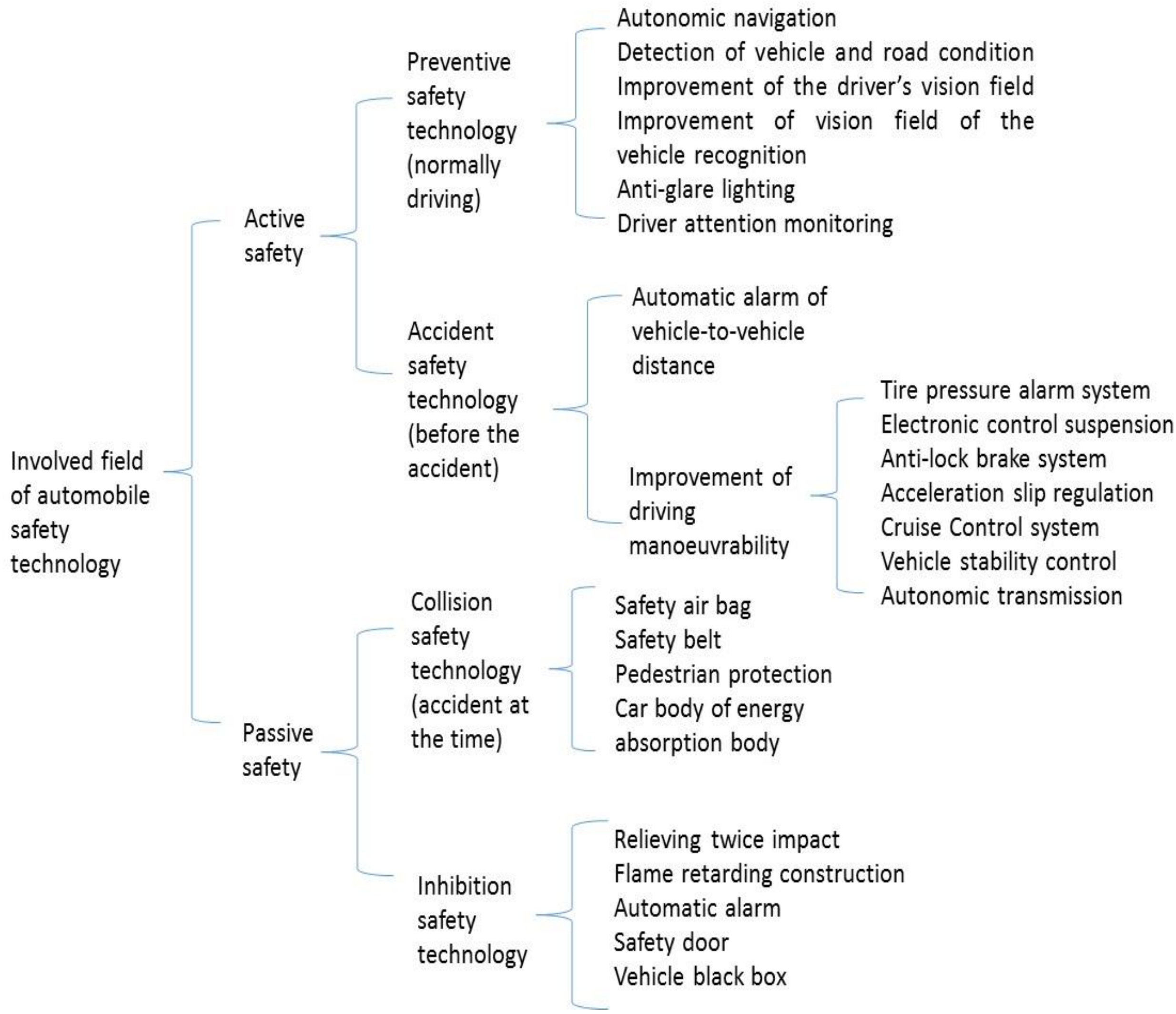

Figure 3: Automotive safety control concept (adapted from Chen *et al*., 2013, p. 329).

Aspects of performance in vehicles are due to the development of these technologies both active and passive; however, the extensive application of these new technologies in vehicles yield challenges for the operator because the design, calibration, and control systems become more complex in nature (Chen *et al*. 2011).

Road condition:

The environmental factors when driving contribute to the traffic incidences. Essentially the research on road conditions plays a pivotal role in the overall driving experience of the operator as the road conditions affect the active safety technology; (Wang and Pei, 2014). Road conditions impact on elements such as the control braking systems, vehicle stability, and collision avoidance systems (Chen *et al*., 2013; Wang and Pei, 2014). The road materials, road conditions, tyre types, pressure, and vehicle velocity also affect the road coefficient of friction, which may give an indication of the road friction condition (Wang and Pei, 2014). Some of the examined road surfaces include: dry asphalt, wet asphalt, dry cobblestone, wet cobblestone, snow, ice, and gravel road (Wang and Pei, 2014). Therefore, as mentioned by Wang and Pei (2014) since roads are different they will also correspond differently to slip ratio, control accuracy and control effects of the vehicle. Development of road conditions identification will help improve the control quality of the automotive electronic control braking system. El Falou *et al*. (2003) add that vibrations are often felt from different road conditions and it may cause a certain level of discomfort, which may affect the driving ability of the operator.

Driving Duration:

The effect of driving duration (i.e. increased driving time or time on task) on driving performance decreases alertness in drivers and forms part of the sleep-related incidents in driving (Otmani *et al*., 2005). Long duration drives which are often monotonous in nature are ostensibly linked to factors pertaining to boredom, fatigue, and impose on the attentional resources and information processing ability of the drivers (Wang and Pei, 2014).

Internal factors:

As mentioned in preceding sections, internal factors also form part of the concept surrounding driver distractions (Regan *et al*, 2011). Essentially the internal factors affect the driver and are interior to the vehicle. The motorist does not necessarily have full control of these factors as they are also influenced by biological, genetic predisposition, mood and personality traits of the motorist. This section aims to give a brief account of some of the sub-concepts pertaining to internal factors.

2.3.2 Relevant Driver's characteristics

Monotony:

Broadly, monotony refers to repetitive and uniformity of a task, activity, sound and/or scenery (Antonson *et al*., 2009). Gilberg and Akerstedt (1998, p. 599) describe monotony as the "extent to which the task is paced". Various studies have explored and investigated the effect of the state of the human being under a monotonous situation (Antonson *et al*., 2009; Lacrue *et al*., 2011). Pertaining to driving related research, monotony refers to the tedious task associated with driving a vehicle, the repetitiveness of the stop-start motions, the monotony of the road in terms of the geometry, repetitive and mundane routes and environment (Antonson *et al*., 2009; Lacrue *et al*., 2011). The investigation of monotony on behaviour, physiological state and performance of an individual is well documented indicating that monotony is likely to gradually decrease an individual's overall performance and is a casual factor in other psychophysiological states experienced by human beings such as boredom, boredom proneness, and fatigue. These may later affect driver vigilance, blink frequency and may eventually cause discontinuation of the task all together; and this is referred to as task aversion (Campagne *et al*., 2005; Antonson *et al*., 2009; Lacrue *et al*., 2011).

The concepts around monotony, boredom and fatigue illustrate the huge deficit with regards to individuals maintaining vehicular control, and this sums up a large portion of the causes of road accidents that occur daily (Thiffault and Bergeson, 2003). According to Lacrue *et al*. (2011) an individual driving more than 30 minutes on a monotonous road is likely to endure some physiological impairment such as an increase in blink frequency and blink duration, boredom and time on task fatigue, which may ultimately affect driving performance. Moreover, it has been found that the increased risk of accidents occur on long, level straight stretched roads and open terrain rather than closed forested terrain (Antonson *et al*., 2009). Lacrue *et al*. (2011) agree and suggest that monotony related crashes occur mainly on highways and structured roads which fits the description above. The combination of a monotonous task and a monotonous environment results in crashes as one suffers from lapses of vigilance and reduced situation-awareness which implies the inability for the driver to perceive, comprehend, interpret and execute relevant driving tasks (Yamakoshi *et al*., 2009; Lacrue *et al*., 2011). Subsequently, various studies sought to investigate monotony in detail with regards to driving performance and transport operational systems (Thiffault and Bergerson, 2003; Lacrue *et al*., 2011). In summary, monotony reduces various physiological attributes and demonstrates signs of boredom and fatigue; and various research has indicated the relationship between objective measures within (perceptual, cognitive, motor impairments) domains along with evoked emotional, and motivation of boredom and fatigue which are subjective in nature (Culp, 2006).

Boredom:

The concepts of boredom and boredom proneness are worthy of enquiry as they are largely associated with the monotony of a task-at-hand and the state of under arousal attributed to inadequate stimulating environment or situation (O'Hanlon, 1981; Heslop, 2014). Boredom and boredom proneness in driving research thus indicates that driver behaviour is compromised as drivers find methods to alleviate the boredom experienced while driving (Heslop, 2014). These methods of alleviating boredom are therefore referred to as driving distractions, which pose as risk factors to the performance of the driver. Being in a state of boredom may elicit emotional and motivational responses largely associated to individual differences and personality traits (Culp, 2006; O'Hanlon, 1981). Literature related to boredom indicates the large variability amongst individuals with its ability to occur within minutes to hours of the commencement of a task as experiencing boredom is a relative concept (O'Hanlon, 1981). It has been shown that the reversed state of an individual experiencing boredom is through a change of the environment, receiving visual or auditory stimuli, and/or changing the task all together (O'Hanlon, 1981). As a result facets associated to driving performance are hindered or worsened by an individual's degree of boredom (Heslop, 2014). Consequently, boredom has the potential to gradually reduce task performance, i.e. driving performance, which includes performance efficiency, mental capacity, and satisfaction of an individual (O'Hanlon, 1981).

Performance efficiency

In the context of driving, performance efficiency would refer to the driver's ability to maintain steering control, lateral control of the vehicle, lateral speed and the braking response due to external unforeseen stimuli in the quickest time possible (Roidl *et al*., 2013). Therefore performance efficiency in driving is of monumental proportion in the literature, based on the number of accidents and traffic fatalities associated with the task of driving. As a result facets associated to driving performance are hindered or worsened by an individual's degree of boredom (Heslop, 2014).

Mental Capacity

Whilst research on boredom affecting the mental capacity of individuals is unclear, O'Hanlon (1981) states that persons who demonstrated strong feelings of resentment, repressed hostility, feelings of anxiety and depression often suffered from chronic boredom. Sunshine (2013) showed that the ability of an individual to process information is dependent on factors such as motivation, as motivation, which affects overall involvement of the individual. The importance of motivation is ostensibly linked to the concept of boredom as it has been seen that boredom affects one's psycho physiological state and reduces one's motivational resources to complete a task. With that said a decrease in motivation through the state of boredom may diminish cognitive efficiency of an individual ultimately affecting the task to be performed at hand (Hoffman, 2012; Sunshine, 2013).

Satisfaction

The natural occurring feelings and emotional responses to boredom would elicit feelings of fatigue and possibly aversion to the task (Ettema *et al.*, 2012; Sunshine 2013). Literature indicates that satisfaction while driving depends on the driving conditions such as road layout, road geometry, and crowdedness (Ettema *et al*., 2012; Ettema *et al*., 2013). It can be said that satisfaction is indirectly proportional to the extent of the monotonous environment and task thereby decreasing satisfaction of the driver, which again may reduce performance efficiency of the motorist. Ettema *et al*. (2012) state that recent research on travel satisfaction indicates that the anticipated trip activity of the traveller differs from what is experienced by the traveller; thus accentuating the need for further investigating factors that underlie trip decision making as well as anticipating the actual experience of the trip (Ettema *et al*., 2012). Engaging with research of this nature provides a foundation in investigating personality traits with the association of coping strategies under a monotonous driving condition as well as transforming the perceptions and driving behaviours of motorists who deliberately seek relief to alleviate the experience of boredom (Ettema *et al*., 2013).

Individuals with a high optimum level of arousal are more prone to boredom (Leong and Schneller, 1993). In non-specific terms it has been found that individuals overestimate both positive and negative emotions before a trip (Ettema *et al*., 2013). This overestimation may be the plausible explanation to individual decision making processes and behaviours conducted in traffic. Using subjective well-being and satisfaction scales Ettema *et al*. (2013) were able to determine the extent motorists are influenced on the road in terms of experiences of satisfaction. The results illustrated a correlation between the underlining criteria of the Satisfaction Travel Scale; namely, positive activation, positive deactivation, and cognitive evaluation- these are indicative of the overarching construct of satisfaction when driving (Ettema *et al*., 2013).

For purposes of this study the factors of Satisfaction Travel Scale will be described briefly. Firstly, positive activation refers to the motorists who are affected positively from low trip frequency; the motorists experienced traffic safety while driving, and were not annoyed by other motorists (Ettema *et al*., 2013). Positive deactivation refers to motorists who are less distracted by external visual stimuli such as billboards, with the research indicating that men have a higher level of positive deactivation than women (Ettema *et al*., 2013). Lastly cognitive judgements are experienced when the trip is either for recreational purposes, unlike driving on a monotonous highway (Ettema *et al*., 2013). Motorists are able to make their own decisions with regards to the choice of speed, lane changes and so on. It can be assumed that when motorists are having a negative driving experience through the high trip frequency (traffic jam), less autonomy with regards to lane changes and speed this will elicit negative activation and therefore dissatisfaction of the driving experience and the trip in its entirety.

Boredom proneness:

Boredom proneness is therefore a facet of boredom that has gained considerable interest with regards to research in human factors that create a decrease in driving awareness as it affects a multitude of dimensions and contributes towards the complex physiological phenomenon such as fatigue (MacDonald and Holland, 2002). Earlier research conducted by DeChenne (1988) points towards the fact that boredom proneness was the "tendency of certain persons to experience frequent boredom" (Leong and Schneller, 1993, p. 234). Leong and Schneller (1993) say that inadequate stimulation of an environment will bring forth four factors which will induce boredom proneness. The first of these factors relates to an individual's optimum level or arousal or customary activation, which is said to involve the psychological and physiological activation of the central nerves system (CNS) (Leong and Schneller, 1993). Second is the ability for one to orientate internal and external sources of stimulation (Leong and Schneller, 1993). The third factor involves the extent to which the needs and interests are met. In the context of driving, the motorist arriving safely at the predetermined destination would be considered a conscious need (Leong and Schneller, 1993). Lastly the level of intellectual, aptitude, creativity and social skills influences an individual's attempt to seek stimulation as a way of reducing the boredom. Boredom proneness marks the beginning of investigating sleep-related issues surrounding fatigue, thus these broad topics are readily investigated in driving research. Sleepiness and fatigue concepts are therefore discussed in the next section.

Sleepiness and Fatigue:

The investigation towards sleepiness and fatigue is relevant as it has been shown to affect concentration, attention and performance in some instances (Shen *et al*., 2006). Whilst sleepiness and fatigue are said to be interchangeable concepts, both distinguished differently indicating the difference of the two concepts. Sleepiness is therefore considered a ubiquitous phenomenon that affects most individuals over a 24 hour period, and also accounts for the probability for one to fall asleep due to the posture, situation and/or time (Craig *et al*., 2006; Shen *et al*., 2006). Although mechanisms that cause sleepiness are not well understood, conceptual models are used to explain the propensity for one to experience a level of sleepiness throughout the day (Shen *et al*., 2006). Sleepiness is therefore determined by sleep drive and wake drive of which each drive consists of primary and secondary components (Shen *et al*., 2006). On the one hand the primary drive refers to the components of the neuronal activity of the central nervous system driven by the circadian and ultradian rhythm (Philip *et al*., 2005; Shen *et al*., 2006; Matthews *et al*., 2012; Gastaldi *et al*., 2014). On the other hand, the secondary drive refers to the effect of homeostasis, behavioural factors as well as environment factors such as posture and lighting and possibly the boredom proneness experienced (Philip *et al*., 2005; Shen *et al*., 2006).

Driving a vehicle invokes a specific and set environment, whereby an individual is restricted in the way he/she can physically adjust himself/herself to fit in the car and therefore this restricted environment may bring forth certain emotions such as irritability, annoyance and boredom-eventually sleepiness and/or fatigue. Evidence shows that nearly all motorists feeling drowsy and sleeping behind the wheel are three times more likely to be involved in near road traffic accidents (Matthews *et al*., 2012). Literature reveals that about 20% of the total accidents occurring every year are due to sleepiness (Lal and Craig, 2001; Gastaldi *et al*., 2014). Shen *et al*. (2006) emphasise that sleepiness is caused by an imbalance of sleep/wake mechanisms whereas fatigue may result from an imbalance of sleep/wake mechanisms and other related factors.

Fatigue has been deemed a life threatening and debilitating state particularly in situations that require one to be alert (Shen *at el*., 2006). The very phenomenon however is considered a complex one, one that has many definitions and is multifaceted in nature (Louw, 2013). In this context fatigue refers to the extreme sustained state of exhaustion, often recognised by an individual's incapability to complete motor and cognitive tasks, impacting on attentional resources and information processing ability (Shen *et al*., 2006).

Fatigue can further be catergorised into two states: physical fatigue and mental fatigue. Physical fatigue often results in loss of muscle strength, discomfort, pain, nausea and blurred eyes (Louw, 2013). Physical fatigue stems from both the dynamic and static muscular work of which over exertion may lead to either of the symptoms mentioned above. According to Boksem and Tops (2008) mental fatigue is suggestive of the reduction or impairment of cognitive and behavioural performance often as a result of demanding a task and the time of the task. However, studies have shown that prolonged working hours do not necessarily lead to a state of mental fatigue and is therefore seen as an effort/reward imbalance (Boksem *et al*., 2006). This imbalance refers to the notion that one would invest either more or less time depending on the sufficient reward (Boksem *et al*., 2006). Furthermore, literature expresses individuals reporting difficulties in concentrating and remaining focused on the tasks, generating feelings of de-motivation and negative emotional responses to cease or disengage from the task altogether, and this is referred to as aversion (Hockey, 1997; Fairclough and Roberts, 2011). Aversion exists as a by-product of the sustained effort put into a task (Hockey, 1997). Literature indicates that aversion is as a result of mental fatigue as well as decision making principles. Fairclough and Roberts (2011) highlight that the strategic decision making to either invest and/or withdraw from mental effort is parallel with motivational disposition to approach and avoid (Boksem *et al*., 2005, p. 292; Polman, 2012). Despite these findings, individuals are prone to driving errors, reduced performance and increased risk with the decline of mental ability; as the use of cognitive effort supersedes that of physical effort particularly in the context of driving (Louw, 2013).

Research findings further associate fatigue with a theoretical framework established by May and Baldwin (2009) that defines fatigue as either being active or passive (Gastaldi *et al*., 2014) with active fatigue referred to as prolonged, continuous bouts of perceptual motor demands, and overload of the task at hand. Gastaldi *et al*. (2014) describe causation of active fatigue in the driving context being high traffic density, extreme weather conditions that increases poor visibility, auditory stimuli from navigation, systems, in-car passenger conversations and so on; whilst passive fatigue is associated with the underload of stimulation, low motor demands and is therefore considered as a monotonous driving situation (Gastaldi *et al*., 2014). The concept of fatigue is therefore explained by a model established by May and Baldwin (2009) illustrating that there are categories of fatigue that may be applied in the driving context (Gastaldi *et al*., 2014). Whilst fatigue remains a complex phenomenon, the possible categorisation may better establish root causes of fatigue as well as define solutions to the problems occurring while being fatigued (Gastaldi *et al*., 2014). The model illustrate in figure 4 below, makes a distinction between sleep-related fatigue and task-related fatigue.

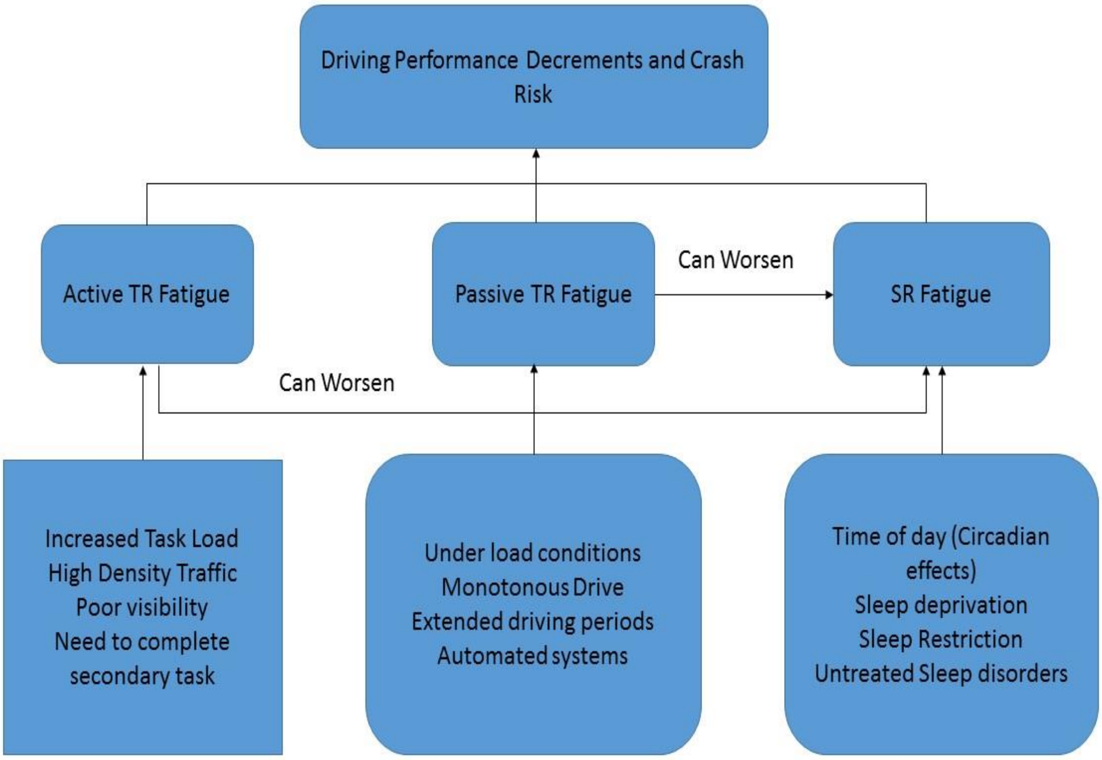

Figure 4: Model of fatigue (adapted from May and Baldwin, 2009, p. 219).

Sleep related fatigue is based on the body's natural circadian rhythm (i.e. time of day), sleep restrictions, sleep disorders and/or sleep deprivation (Gastaldi *et al*., 2014). The circadian rhythm helps control an individual's sleep/wake patterns (Lal and Craig, 2001; Matthews *et al*., 2012; Gastaldi *et al*., 2014). According to Gastaldi *et al*. (2014) the increase of driving accidents occur between 02:00 and 06:00, and between 14:00 and 16:00; these are the times the body is mostly in need of rest. Task-related fatigue, may either be active or passive with active fatigue referring to the driver experiencing intense high traffic density, participating in secondary tasks such as using a cellular phone while driving and operating automated auditory and navigation systems (Gastaldi *et al*., 2014). Passive fatigue is described as the under load of driving conditions i.e. a monotonous and long extended drive with partially or completed tasks impairing a driver's concentrated ability (Gastaldi *et al*., 2014). Brookhuis and Waard (2010) emphasises the magnitude of accidents that occur due to inadequate mental work load which is as a result of high stresses or low vigilance i.e. active fatigue and passive fatigue (Yamakoshi *et al*., 2009).

These concepts discussed previously are imperative in driving performance and each concept is experienced at different degrees dependent on individual differences, and personality traits of the individual as such an individual would find different means of coping with monotony, boredom and fatigue such as listening to music in a vehicle (Ünal *et al*., 2013). Various techniques are used to measure the physiological process occurring as a result of monotony, boredom, and fatigue, signalling possible countermeasures when participating in completing a task (Brookhuis and Waard, 2010).

2.3.3 Distractions in driving

Human error is generally cited as the "most frequent cause of accidents" (Zhao *et al*., 2012, p. 676). Distractions and driver errors are considered important and fundamental concepts in road safety related research, seeing that distractions are predominately the causation of errors (Young *et al*., 2008; Young and Salmon, 2012). Driving errors are said to be a major casual factor in 75-95% of road crashes and a casual factor in road trauma (Young *et al*., 2013). Thus distractions are either external or internal in nature (which may disrupt visual or auditory modalities) of the sensory memory, while behavioural modalities or a combination of all may trigger attention shifts from the main task at hand (Horberry *et al*., 2006; Lansdown, 2012). External distractions are associated with visual clusters, such as billboards, street vendors, poor illumination of traffic lights as well as auditory stimuli (road works, engines etc.), which is considered as environmental noise (Ho *et al*., 2001; Horberry *et al*., 2006). Internal distractions on the other hand constitute in-vehicle traffic; this includes cluster of control technologies within the vehicle such as the navigation system, in-vehicle telephonic devices, radio, compact disk, video, and iPod musical systems (Lansdown, 2012).

Thirty percent (30%) of the internal distractions are as a result if adjusting radio cassette player, and 50% was attributed to the use of the cellular mobile phone while driving, and together they accounted for nearly 80% of the road incidents that occur daily (Brodsky, 2001). Due to the nature and complexity of motorists experiencing external and internal distractions simultaneously, it becomes increasingly difficult at times to accurately locate the source of the distraction and the driving error at a particular point in time. However, research has investigated various distracting factors in relation to others in both field and laboratory studies. Also, subjective measures and self-report surveys were considered to deduce the severity, frequency, and accident association of the various common distracting activities (Young *et al*., 2008; Lansdown, 2012). The common distractions thus emanate from the visual and/or auditory modality, be it texting while driving or listening to music and conversing with a passenger simultaneously (Lansdown, 2012). Thus it may play a negative role in the information processing ability of individuals. This study will discuss visual and auditory distractions and the similarities or differences thereof (Berti and Schröger, 2001; Reimer *et al*., 2010; Berry *et al*., 2013; Brodsky and Slor, 2013; Young and Salmon, 2014).

Visual and Auditory modality:

The sensory memory as illustrated in the human information processing model by Wickens (1984) describes the nature of information is received, of which the visual modality and auditory signals are the most common for getting attention necessary in eliciting appropriate responses (Lee and Chan, 2007). Mishra *et al*. (2013) say that the working memory for both the visual and auditory motions are critical for the cognitive operations that allow for one to observe and track the environment and therefore the interference on the working memory of these two modalities may have serious consequences. Berry *et al*. (2013) mention that visual modalities are said to hold attention less automatically than that of auditory stimuli. This is due to the fact that visual stimuli requires cognitive control, behavioural and neural support (Lee and Chan, 2007; Berry *et al*., 2013). This means therefore that auditory stimuli is likely to take away from the attentional resources (described above) faster than that of visual stimuli, and as described previously, attention is necessary in driving as opposed to driver inattention (Berry *et al*., 2013). This notion is further substantiated by Lee and

Chan (2007) who through reaction time studies, confirm that simple visual reaction time took longer than that of auditory reaction time. The accepted mean values for these two modalities were 180 ms and 140 ms, respectively (Lee and Chan, 2007). Lee and Chan (2007) therefore document that because of this finding, it was postulated that the auditory stimuli would reach the human brain faster that than of the visual stimuli when administered separately.

Moreover, Lee and Chan (2007) document that the visual stimuli and auditory stimuli represented synchronously and in the same direction resulted in the following: the reaction times of those participating were shorter, and the accuracy of the responses were much higher. However, when the two modalities were presented in opposing positions - one modality dominant the other, of which in this case the visual modality dominated over the auditory modality. Still, this is influenced by the context of the environment and task at hand, because in a driving context it can be assumed for one that both modalities are represented in opposing situations most of the time, perhaps again further substantiating the contradictory findings that listening to music while driving enhances or negatively affects performance, as the auditory stimuli may become more dominant in a driving context. The implications of such findings particularly in the driving context therefore gives way to the notion that drivers are likely to process auditory stimuli faster than visual stimuli as the environmental noise and internal sounds may compete for a driver’s attention, with the driver responding far more towards internal sounds, as it is heard much faster than other opposing sounds or visual stimuli. Conversely, behavioural analysis on young and older adults regarding the visual and auditory stimuli obtained by Mishra *et al*. (2013) states that during a response time task, the ANOVA results showed slower response times in auditory versus visual modality, again illustrating the contradiction in reaction time findings of the two modalities.

2.4 EFFECT OF MUSIC ON HUMANS/DRIVERS

Music is considered a universal language as it can communicate feelings, attitudes, and beliefs encapsulated in a song. This notion is greatly attributed to the links found between music and the social behaviour of individuals (Rentfrow and Gosling, 2003;

Cassidy and Macdonald, 2007). Music is found and listened to in many settings, such as restaurants, homes, offices, clubs and cars and is considered a ubiquitous phenomenon (Rentfrow and Gosling, 2003). Studies show that music is said to influence cognitive function and elicit deep emotional responses (Hargreaves and North, 1999; Rentfrow and Gosling, 2003; Cassidy and Macdonald, 2007). Seeing that the task of driving is one that is complex, yet monotonous in nature, most drivers are of the belief that listening to music while driving reduces the risk of experiencing the monotony, boredom and/or fatigue associated with long-distance driving (Ünal *et al*., 2012). The listening to music whilst the primary attention of the listener is focused on another task or activity is known as background music (Kallinen, 2002). In other words, if the motorist's main task is driving from one destination to the other, and of they listen to music while driving, then this is considered as background music (Kallinen, 2002).

Music plays a huge part in human entertainment often eliciting feelings and behaviours in human beings (Nieminen *et al*., 2011; Kaminskas *et al*., 2012; Goulart *et al*., 2012). It has different frequencies and characteristics making each piece of music unique and diverse. Goulart *et al*. (2012) propose that there are different techniques used in classifying different music genres (groups). Goulart *et al*. (2012) state that the genre of music is important to listeners as the style of the music can influence the liking for the genre of music more than the piece itself. The classification of music genres is of a complex nature, ambiguous and subjective (Goulart *et al*., 2012). Musical genres are established according to the musical characteristics of the piece i.e. the tempo, pitch, rhythmic elements and whether the piece is in a major or minor key (Goulart *et al*., 2012; Kawase, 2013). Goulart *et al*. (2012) mention that Short Time Fourier Transform (STFT), Mel-Frequency Cepstral Coelfidents (MFCC's), Wavelet Transform (WT) and some additional parameters were used to obtain feature vectors. These vectors can statistically deduce patterns as simple Gaussian mixture model, and k-nearest neighbour achieving 61% classification for ten musical genres (Goulart *et al*., 2012; Kaminskas *et al*., 2012; Ricci, 2012). Similar techniques have been employed to classify music in its appropriate field. The difficulty with classification of music genres is due to the fact that the general taxonomy of music genres is not well defined and/or established

(Kaminskas *et al*., 2012, Ricci, 2012). Aesthetic perceptions and preferences of the musical genres are exhibited through individual differences, and personality traits where the "cognitive and affective responses are interconnected and constantly interacting as part of the aesthetic processing" (Nieminen *et al*., 2011, p. 1138). Nieminen *et al*. (2011) mention that the aesthetic processing of music is enhanced by previous experiences, knowledge and other personal features of the individual. Therefore, Nieminen *et al*. (2011) concluded that the aesthetic perception of music is formed by a complex network of stimulus, the individual and situation-related matters. This study aims to look at individuals in a specific situation (i.e. simulated driving setting) that is monotonous in nature, coupled with the extent to which personality traits predict the effect listening to music at different intensities has on driving performance.

As mentioned by Rentfrow and Gosling (2003) despite the prevalence of music in everyday living and the links found between music and social behaviour the study of music remained relatively imperceptible especially within social and personality psychology. Furthermore, Rentfrow and Gosling (2003) say that the majority of the research conducted on music and its impact remained comparatively small with nearly 11000 articles published in the years 1965-2002; only seven articles listed music as a subject heading worthy of inquiry. Rentfrow and Gosling (2003) therefore, followed the relatively small research in order to redress the historical neglect toward this phenomenon. Since then a growing body of research has investigated the implication of music: why people listen to music, musical preferences, and the impact music might have while individuals are driving. According to Rentfrow and Gosling (2003), Cattell was among the first researchers to suggest that music could contribute to the understanding of personality. Rentfrow and Gosling (2003) explain that Cattell believed that certain types of music revealed necessary and/or important information about the unconscious aspects of personality. For instance, sensation seeking individuals and extraversion have been positively correlated or attributed to a preference of music such as: rock, heavy metal, punk, music and exaggerated base like dance or rap music, which begs to answer the question-how then does music affect human beings (Rentfrow and Gosling, 2003; Schwartz and Fouts, 2003)? Both Rentfrow and Gosling (2003) and

Tekman and Hortaçsu (2002) suggest that music may serve a purpose beyond the individual providing a vital role in social adaptation and survival, separation-connection, the formation of defining self and within society (Schwartz and Fouts, 2003); some studies have made comparisons with regards to preferences of music, and making denotations about preferences and personality traits or styles and forms of behaviour (Rentfrow and Gosling, 2002; Schwartz and Fouts, 2003). For example Schwartz and Fouts (2003) makes comparisons between different types of music (heavy music, light music and electric music). They illustrate that adolescent individuals who were prone to listening to heavy music are likely to demonstrate intense emotions of anger, sexual aggression, and a more sympathetic view of suicide than those without the propensity to listen to heavy music. Adolescents and young adults who are prone to listening to light music such as pop and dance are said to display personality attributes that pertain mostly to characteristics such as cooperation, responsibility, social acceptance and having confidence in their academic abilities; but in the same light individuals who listen to light music may have insecurities associated with self-esteem issues, accepting their peers, their developing bodies and/or sexual relationships. Schwartz and Fouts (2003) discusses adolescents who prefer eclectic music that is neither heavy nor light, but a combination of the two. They further highlight that adolescent individuals that listen to eclectic music have a propensity to listen to music according to the mood and the context of the situation. For example, listening to music that validates their feelings and mood when they are alone, but listening to another style of music with peers. This illustrates the broadness and nature of music to validate our moods, existence and emotions in the broad context.

In the context of the driver, it has been shown that the automobile is the most popular location for listening to music (Brodsky, 2001; Ünal *et al*., 2012; Brodsky and Slor, 2013). A study conducted illustrated that music was experienced 91% of the time in transportation, 86% in commercial outlets, 46% at home and 5% of the time at the workplace (Brodsky, 2001). While the location where music is mostly experienced i.e. in a transport setting, has great relevance for research, little has been established on the effects of listening to music while driving with regards to personality traits and on the driving performance measures particularly in the South African context

(Hatfield and Chamberlain, 2008). Brodsky (2001) says that music exposure would most likely occur when a person is alone and “in-situations associated with personal choice over music,” (Brodsky, 2001, p. 220). This reiterates the importance of understanding personality traits and the influence of music on their driving performance, as motorists are likely to select music based on preference. Thus an understanding of behavioural changes (positive or negative) with regards to listening to music connected to driving performance is crucial in traffic related research (Brodsky and Slor, 2013).

The automobile today is modified to fit technological devices suited for the operator, such as car-radio receivers, compact-disk players etc. Motorists also go to the extent of fitting the vehicle with amplifiers, equalisers and other features (Brodsky, 2001). However, “Research suggests that the auditory materials in a vehicle may result in cognitive and auditory distractions that impair driving” (Hatfield and Chamberlain, 2008). Brodsky and Slor (2013) therefore emphasise that collisions associated with *structural interference* (adjusting of radio controls, searching music on MP3 files, and changing compact disks) is well known and established, contributing to near-end crashes and accidents estimated at 0.6 - 2.3%. Yet there is little information concerning listening to music in itself. Brodsky and Slor (2013) attributes the absence of information to traffic researchers are oblivious of the risks associated with music, as high profile studies have wrongfully deemed music not to be associated with negative driving performance. In addition, other studies have declared listening to music while driving not to be a risk, but this fails to detail information in context to the situation and factors at hand (Brodsky and Slor, 2013). This is exacerbated by the spread of popular belief that “listening to music, and signing along to the music cause little-to-no risk compared to all other activities that might lead to distraction” (Brodsky and Slor, 2013, p. 383).

Chan *et al*. (2015) state that words seen (on the car radio “screen”) can decrease driving speeds and slow response times of participants, and negative-words-impact changes to the eye fixation time, causing gaze disengagement to linger longer. In addition, negative images influence steering control adversely than positive images, hence it can be assumed that negative words heard through song can have the same effect of driving speeds and response times compared to positive words depending on the playlist of the participants (Chan *et al*., 2015).

2.5 PERSONALITY TRAITS

Personality is seemingly a complex phenomenon defined in a variety of ways (Weiten, 2013). The theories of personality date as far as the 1960's and have evolved since, in order to categorise the characteristics of how an individual behaves relatively over time and more specifically the manner in which people react in a particular environment or situation (Fleeson, 2001; Weiten, 2013). According to Rundmo (2003) and Weiten (2013) the personality of an individual is recognised when an individual has a fairly consistent tendency towards behaving in a specific way across a wide array of situations. DeYoung (2014, p. 35) defines personality traits as the ''probalistic descriptions of relatively stable patterns of emotion, motivation, cognition and behaviour in response to classes of stimuli that have been present in human cultures over evolutionary time''. The term "probalistic" in the context of personality traits therefore implies that these traits involve a chance of variance for each individual and an individual may possess a number of traits. However, these can gravitate toward a dominant trait, which does not necessarily exclude all other traits (DeYoung, 2014). Various methods have been used in order to distinguish one individual from the other, although many individuals may possess many similarities, all human beings are unique in nature. This distinctiveness in personality helps explain why people behave as they do in similar situations (DeYoung, 2014; Zhou, 2015). Consequently the differences in personality seem to play a pivotal role in evaluating human factors concepts as different personality traits will perform certain tasks differently and therefore selecting the "right" individual to complete a specific role increases the morale of the individual and alleviates human factor errors (Weiten, 2013). An investigation towards personality may explain the stability over a person's behaviour over time and across different or similar situations, as well as corroborate behavioural differences among individuals (DeYoung, 2014; Zhou, 2015). Therefore personality traits is defined as the set of unique consistent behavioural characteristics of an individual (Weiten, 2013; DeYoung, 2014). Researchers have used personality traits to deduce or understand how individuals are likely to perform in different contexts such as academic, how someone is likely to treat the environment, and how individuals respond to physical and/or mental health (Sharpe et al., 2011; DeYoung, 2014; Zhou, 2015). What is also of importance is that certain “personality traits have been shown to be related to risky driving and crash involvement” (Taubman-Ben-Ari *et al*., 2004, p. 323). Therefore, how certain traits exhibit themselves in the context of listening to music while driving might give a better indication towards the inclination for people to behave in a certain way when driving and listening to different music intensities/loudness (Adrian *et al*., 2011).

2.5.1 Schools of Thought

In personality psychology study various schools of thought sought to define personality as a measurement tool (Weiten, 2013). There are four main domains that aimed at understanding human characteristics and behaviours and therefore personality; these perspectives or views are known as the psychodynamic perspective, behavioural perspective, humanistic perspective, and lastly biological perspective (Weiten, 2013). The theories will be discussed briefly in order to illustrate the dynamic theories that are now considered part of and related to the overall view of personality.

2.5.1.1 Psychodynamic perspective

The psychodynamic perspective view includes the diverse theories that are focused on the unconscious mental forces (Weiten, 2013). The main findings and conclusions in this domain were established by scholars named Sigmund Freud, Erik Ericson, and Alfred Adler. Sigmund Freud thus proposed that personality is divided into three components: the id, the ego, and the superego (Austin *et al*., 2009; Weiten, 2013). Freud suggested that the id component housed the natural biological urges to eat, sleep, defecate and so on- and the id operates according to the pleasure principle, which seeks immediate gratification of its urges (Weiten, 2013). The id refers to instincts and drives (Austin *et al*., 2009). The ego is the component that attempts to control the expression of the id (Austin *et al*., 2009). Lastly, the superego is associated with one’s conscience, which functions towards deducing the differences between right and wrong (Austin *et al*., 2009). Freud believed that the mental structures of these components are strongly influenced by the upbringing of the individual and the relationship formed with the parents (Austin *et al*., 2009).

2.5.1.2 Behavioural perspective

The behaviourist theory was first proposed by the following scholars such as Pavlov, Watson and B.F Skinner who deduced from experimental work that the pattern of behaviours is learnt through a number of processes and mechanisms such as habituation which is “the process an individual ceases to respond to stimuli after repeated presentations” (Austin *et al*., 2009, p. 61). Habituation can occur naturally and unconsciously; the individual at times is unaware that he/she is adapting behaviours through habituation. According to Austin *et al*. (2009) behaviours are also established through sensitisation, which refers to the process with which individuals become sensitive to proprioceptive and aesthetic modalities such as pain, smell, touch, sound and other senses (Austin *et al*., 2009). Sensitisation can however, also lead to maladaptive processes when an individual is sensitised to ‘harmful’ stimuli. Therefore an individual can be conditioned into behaving in a certain way through positive (reward) and/or negative reinforcement (avoidance) (Austin *et al*., 2009). Skinner further proposed that human being behaviour was part of nature, and that in order for one to experience favourable responses one should develop positive traits that would emphasise positive human behaviours- the opposite is also true (Austin *et al*., 2009). Lastly, the concept of modelling based on the work conducted by Albert Bandura illustrated that behaviours can be learnt without the direct processes of habituation, sensitisation and/or conditioning, but can also be learnt through observations (Austin *et al*., 2009). Bandura’s work illustrated that children were able to learn behaviours by paying attention to something, retaining the stimuli noticed and later reproduce what was observed.

2.5.1.3 Humanistic perspective

This perspective challenges the preceding perspectives which are based on internal or external forces. The humanistic perspective differs with the behavioural one as it states that human beings choose how to act in different situations (Austin *et al*., 2009), implying that each human being creates his/her own experience(s) (Austin *et al*., 2009). Raskin (2012, p. 126) discusses the postulated theories established by Bugental's (1978) work on the humanistic perspective, such that the humanistic approach "sees people in non-reductionist terms, as the second hypothesis suggested that people cannot be understood in isolation, such that understanding human connectedness, and embeddedness in interpersonal relationships and cultural milieu is vitally important." The third hypothesis states that people are aware of their existence and thus the awareness is what assists individuals in informing their decisions, which then falls into the fourth theory emphasising the ability for individuals to make choices based on their awareness, thus reinforcing Austin *et al*. (2009) stance on the humanistic perspective (Raskin, 2012). The final and fifth hypothesis by Bugental focuses on intentionality - in other words, humans have purposes, reasons, assignments and/or dreams to fulfil in order to validate the meaning in experience (Raskin, 2012). Carl Rogers' work showed that humans undergo constant growth by forming and reforming constantly, while Abraham Maslow's study emphasised an individual's human needs. Therefore taking all of this into consideration, the personality of an individual is influenced by the genetic predisposition, environment, upbringing as well as conditioning influences (Raskin, 2012).

2.5.1.4 Biological perspective

The biological perspective takes into consideration the genetic and heritability of personality, and takes into account the neuroscience and evolutionary perspectives concerning personality based on the work conducted by Hans Eysenck. Eysenck's research predominantly viewed personality in a hierarchical structure of traits, establishing that there were a number of underlining or superficial traits beneath a higher-order of traits; namely, extraversion, neuroticism, and psychoticism (Weiten, 2013). However, Eysenck's work also claimed that personality were results of genetic predisposition and inherited conditioning concepts; implying that one 'type' of people was more susceptible to be readily conditioned versus another type of personality characterised by inherited differences in physiological functioning

(Weiten, 2013). The concept of genetics playing a role in personality was substantiated by research conducted on identical and fraternal twins. The research went on to demonstrate that identical twins who were separated at birth, after a number of years illustrated to have similar scores and high correlations in the Big Five traits as opposed to fraternal twins (Weiten, 2013). This test finding in twins gave weight to the notion that 50% of an individual's genetic composition also informs personality type. As Hartmann (2006) states that nearly 30-50% of the phenotype variance in individuals can be explained by genotypic variance, but Hartmann (2006, p. 161) recaps that a readjusting of the scores accounting for confounding variables in the estimation of super-traits would increase the support regarding the heritability theory to a score of 60-70% of the phenotypical variance accounting for an individual's personality persona, so the remaining 30-40% of the phenotypic variance can be explained by the non-shared environments (environmental factors not shared by family members).

2.5.2 BIG FIVE PERSONALITY FACTORS

Research in a variety of fields has consistently confirmed the Big-Five personality factors as a relevant and valid dimension of personality which reliably predicts differences between individuals; and its theoretical and empirical importance have repeatedly been demonstrated (Taubman-Ben-Ari and Yehiel., 2012, p. 417). As mentioned by Milfont and Sibley (2012) the Big Five emerges as a result of methods in factor analysis of ratings of adjectives in many languages and personality questionnaires that weren't necessarily designed to measure the Big Five. The Big Five personality framework simply summarises the main five traits that are consistently seen in behaviours of individuals. Literature identifies differences in behaviour when motorists listen to specific music (Brodsky, 2001). Different types of music may either influence motorists' rhythms of driving, concentration, and would either relax motorists or charge their stimulation (Brodsky, 2001). In addition, Crawford and Strapp (1994, p. 238) states that an increased physiological arousal may result in increased susceptibility to distractions; those individuals who are more susceptible to the over arousal effect are likely to be over-aroused by the music listened to and are likely to have worsened driving performance ability. Furthermore according to Crawford and Strapp (1994, p. 237) "music may possess unwanted and annoying characteristics similar to noise, or it may be perceived as a facilitator of performance due to its soothing or stimulating qualities depending on the individual. Music has been known to facilitate, reduce, or have no effect on performance. The distracting qualities of music may depend upon its type and its decibel level." Consequently, this study aims to investigate these phenomena. For clarification, this study will therefore define the Big Five personality traits, and describe how each personality trait is likely to respond in a driving situation, as well as explain the responses to music in the driving context.

2.5.2.1 Extraversion

Individuals who score high in extraversion are described as people who are extremely social amongst their peers (Taubman-Ben-Ari and Yehiel, 2012; Rauthmann *et al*., 2015). Extraversion is a personality trait that tends to be assertive and often displays cheerful behaviour in social interactions outgoing nature, chattiness, energy, adventure, and such characters are reticent and sensation-seekers (Milfont and Sibley, 2012; Taubman-Ben-Ari and Yehiel, 2012). In the context of driving however, studies have demonstrated that extraversion personality types fail to cope in prolonged and monotonous driving situations due to their personality structure which is constantly in need of external or internal stimulation. Therefore, they are prone to listening to high intensity music in the driving context to alleviate the monotony and are therefore more susceptible to making errors. The Multidimensional Driving Style Inventory Scale advocated by Taubman Ben-Ari *et al*. (2004) has successfully identified the driving styles of individuals associated with these personality traits. Moreover, their research findings suggest that sensation seekers and/or extraversion are positively adversely linked to riskier driving behaviours or high-velocity driving styles, and is inversely associated with patient driving style.

2.5.2.2 Agreeableness

Agreeableness individuals tend to demonstrate warm and kind feelings toward other people. Individuals who score high in agreeableness are also described to be amiable, modest, considerate, cooperative, tolerant, showing concern for others. Agreeableness people tend to be trustworthy and all extremely helpful (Dahlen *et al*., 2012; Taubman-Ben-Ari and Yehiel, 2012). However, low scorers of this category tend to be less co-operative, cold, suspicious, and perhaps inconsiderate amongst many other negative attributes (Milfont and Sibley, 2012).

2.5.2.3 Conscientiousness

People who score high in conscientiousness are said to have the following attributes: organised, moral and achievement-orientated, efficient and responsible (Dahlen *et al*., 2012; Taubman-Ben-Ari and Yehiel, 2012). Furthermore, conscientious people are said to be disciplined individuals who are thorough in all that they do, efficient and responsible (Milfont and Sibley, 2012).

2.5.2.4 Neuroticism

A neuroticism person shows traits that lean towards a depressive state of being. Neuroticism is also associated with traits such as anger, high levels of anxiety and insecurity (Adrian *et al*., 2011; Milfont and Sibley, 2012). According to Milfont and Sibley (2012), neuroticism as a personality traits seeks the closeness of relationships perhaps as a means of establishing worth and inclusiveness into society.

2.5.2.5 Openness

Last of the Big Five traits is openness. This trait is identified in individuals who tend to embrace new challenges, opportunities and/or experiences that come into being (Milfont and Sibley, 2012). Openness individuals are curious and flexible in nature (Dahlen *et al*., 2012; Weiten, 2013). Milfont and Sibley further state that openness people are more tolerable of all other people, have imaginative minds and are fairly intelligent in nature. This study will further review evidence in connection with how each personality trait is likely to respond in a driving context situation.

2.6 PERSONALITY TRAITS IN THE CONTEXT OF DRIVING

Rundmo (2003) mentions that the investigation of the role of personality traits and traffic involvement dates back to the 1930's when Farmer and Chamber first postulated the theory of 'accident proneness'. The theory suggested that the 'majority of the traffic accidents were caused by a minority of individuals who possessed certain personality characteristics' (Rundmo, 2003, p, 429). However, Farmer and Chamber's theory was regarded as unsatisfactory and despite this conclusion, personality traits have shown to be consistent in traffic accident involvement in spite of the fact that most research considers the use of personality traits as a feeble indication of traffic accident findings and/or involvement (Rundmo, 2003). Since then a variety of scholars have sought to predict the role of personality in different contexts such as academic, daily life, job performance, driving behaviours and traffic accident involvement using a plethora of methods; some in the form of empirical study and others in non-empirical methods or both (Trimpop and Kirkcaldy, 1997; Fernandes *et al*., 2002; Rundmo, 2003; Dahlen *et al*., 2013; Panayiotou, 2015; Qu *et al*., 2015; Rauthmann *et al*., 2015). Rundmo (2003) mentions that personality traits and accident involvement may be underestimated and general measures of personality traits on accidents are generally weak predictors. The more appropriate method would be to "single-out" different "aggressive" behaviours across situations as attempted to be done in this dissertation. Rundmo (2003) proposes that a multiple-act criterion is the most appropriate and reliable form in investigating the influence of personality on behaviour. With that said Rundmo (2003, p. 429) further mentions that by using this above-mentioned assumption "one can expect personality traits to be more successful in predictors of aggression of different risk-taking behaviours in traffic as compared to accident frequency.'' Classen *et al*. (2011) add that the use of personality theory is a modest, yet consistent predictor of risky behaviours in driving. This section of the dissertation aims to give an account and findings related to the different traits and its association in driving behaviours or ability.

Personality traits that show an effect on driving

In a cohort study, Fine (1963) found that extraverts are more likely to commit road violations and incur more accidents as opposed to introverts (Trimpop and Kirkcaldy, 1997). Trimpop and Kirkcaldy (1997) who also document findings by Shaw and Sichel (1970) stated that neuroticism extraverts are more prone to be involved in accidents. In 1979 Loo showed that the impulsivity subcomponent of extraversion is also linked to fluctuated susceptibility to road accidents and inferior driving ability. Characteristics of this personality trait (extraversion) have been found to display attributes of sensation-seeking or adventure-seeking, impulsivity, fearlessness, reduced self-control and self-esteem attributes from which are said to be more accident prone (Trimpop and Kirkcaldy, 1997; Begg and Langley, 2001; Rundmo, 2003;Schwebel *et al.*, 2007; Le Bas *et al*., 2015). Further work on this phenomenon conducted by Furnham and Saipe (1993) investigated the relationship between personality traits and those who were convicted of road offences (speeding and reckless driving) and non-convicted drivers (Trimpop and Kiskcaldy, 1997). The two authors stated that convicted drivers scored higher results in the psychoticism dimension and lower in neuroticism coupled with high thrill and boredom susceptibility, implying that extraverts dislike mundane activity or routine like long-distance driving (Trimpop and Kirkcaldy, 1997). Rundmo’s (2003) findings can be summarised into the following categories: the perception of risk of traffic, the attitude toward traffic safety and lastly the risk-taking traffic behaviour. (See Table III).

Table III: Summary of the findings of Rundmo (2003) for the perception of risk of traffic, the attitude toward traffic safety, and lastly the risk-taking traffic behaviour.

Traits	**Perception of risk of traffic**	**Attitude of traffic safety**	**Risk-taking traffic behaviour**
Sensation-seeking	Lower	Negative	Higher risk-taking
Altruism	Higher	Positive	Less risk-taking
Anxiety	Higher	Positive	Less risk-taking
Normalness	Lower	Negative	Higher
Aggression	Complex pattern of behaviour, but higher than individuals scoring low in this trait	Negative	More risky behaviour

In this instance Rundmo (2003) does not use the Big-Five inventory to define personality traits, but does use characteristics associated to those traits which are derived from the NEO-Personality Inventory. Sensation–seeking is associated with the need for excitement and stimulation. Altruism is the characteristic where one is actively concerned for others (Rundmo, 2003). Anxiety is the proneness towards fearfulness, constant worry, nervousness and stress, and lastly normalness is defined as the belief that socially unapproved behaviours are required to achieve certain goals (Rundmo, 2003). Given the definitions of the Big-Five inventory traits it is feasible to assume the link for example between extraversion and sensation-seeking. Therefore, it is plausible to conclude that extraverts are likely to perceive risk in traffic as low, due to the nature of requiring excitement and stimulation, and thus are more prone to higher risk-taking behaviours whilst driving (Rundmo, 2003). Rundmo (2003) mentions that the perceptions of risk of traffic and the attitude toward traffic safety are correlated to the risk-taking traffic behaviours.

Work conducted by Dahlen *et al*. (2012) proposed a model of analysing six aspects of driving personality, which included the driving anger and the five factor model (extraversion, agreeableness, conscientiousness, emotional stability and openness). These were used as predicators of two outcomes crashes and moving violations. The model was conceptualised as follows (Figure 5). The model predicts that there would be a positive or negative relationship between the six aspects on aggressive driving, and then a positive relationship of aggressive driving on driving performance. Dahlen *et al*. (2012) posit that driving anger and extraversion would have a positive relationship on aggressive driving and therefore on driving performance. Therefore driving anger may be associated with aggressive driving, as it has been found that individuals with a higher level of driving anger are likely to express anger across a wide range of driving situations which could interfere with driving ability and driving safety (Dahlen *et al*., 2012). The other traits like emotional stability, openness, agreeableness and conscientiousness all have a negative relationship with aggressive behaviours. In other words, emotional stability characterised by trends of being relaxed and even-tempered thus an emotionally stable person show fewer signs of aggression even under stressful situations (Dahlen *et al*., 2012). Conversely, individuals low on emotional stability are categorised as having neuroticism which is associated with being less calm, experiencing more anxiety, depression, worry and poor coping ability in strenuous situations. Therefore, Dahlen *et al*. (2012) suggest that less emotionally stable individuals are likely to be easily angered increasing the possibility of riskier driving behaviours.

Openness according to Dahlen *et al*. (2012) is said to have a negative relationship with aggressive driving because openness is associated with a more realistic view-point of situations and situational based attributes. Openness allows individuals to respond more positively to a negative situation. For example, an individual with the trait openness would not assume another driver is a bad driver because this driver has cut in front of him; the openness driver would first assume that the other motorist did not see him and that it was an honest mistake (Dahlen *et al*., 2012). The reason for agreeableness having a negative relationship is based on the fact that this trait is associated with soft-heartedness, cooperative and conscientiousness attributes hardly showing signs of aggressive driving because of attributes that are efficient, responsible and a moral-compass (Dahlen *et al*., 2012).

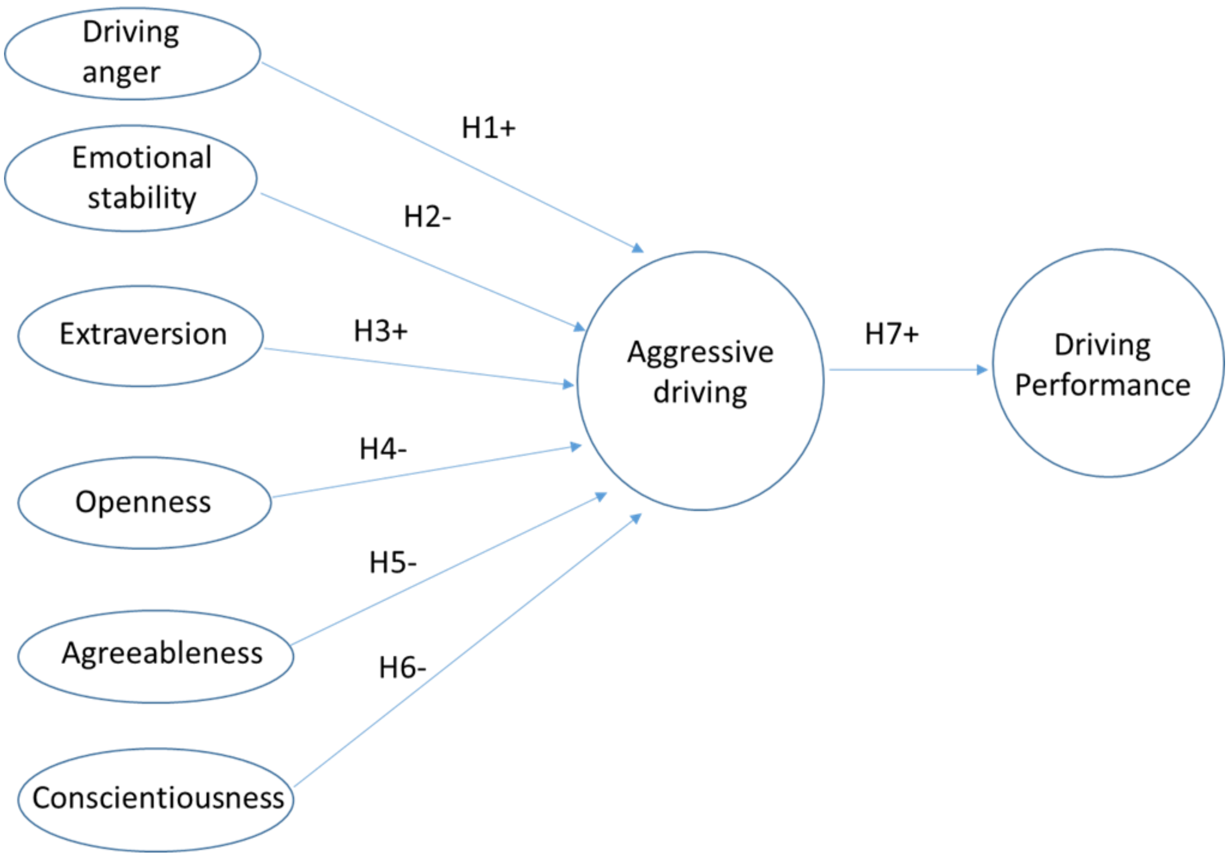

Figure 5: The hypothesised model of aggressive driving behaviour. The specific hypotheses are labelled on each path (adapted from Dahlen *et al*., 2012, p. 2).

With the proposed hypothesis Dahlen *et al*. (2012) found that zero-order correlations showed that H1 (driving anger), H2 (emotional ability), H4 (openness), and H7 (aggressive driving to driving performance) were supported by the data; however, "bivariate relationships do not take into account the joint effects of all variables in the model", thereby not providing accurate results of the hypothesised relationships. A structural model approach was thus conducted by Dahlen *et al*. (2012). Of the six predicators 36% accounted for the variance in aggressive driving and 7% of the entire data model explained the variance on driving performance. H1 (driving anger), H5 (agreeableness) and H7 (aggressive driving to driving performance) were supported, however H2 (emotional stability), H4 (openness), and H6 (conscientiousness) were not supported by the data from the student equation model. These include emotional stability; openness and conscientiousness were not related to aggressive driving (Dahlen *et al*., 2012).

Personality traits that show no effect on driving

The trait altruism may be considered synonymous to the definition of agreeableness (Rundmo, 2003). Results regarding this trait show that high scores in agreeableness or altruism indicate less risk taking behaviour in the context of driving (Table III). That is, agreeableness is negatively associated with aggressive driving or driving performance, showing that agreeableness participants aren't likely to be involved in riskier driving patterns or crash involvement. Agreeableness participants do not make part of the 7% variance shown to contribute towards negative driving performance.

Seemingly conscientiousness motorists may not show signs of aggressive driving behaviours, because conscientious individuals are self-disciplined individuals and show signs of responsibility and are therefore more likely to follow the rules and regulations of the road (Milfont and Sibley, 2012).

As mentioned by Dahlen *et al*. (2012) those who score low in emotional stability and high neuroticism are likely to respond negatively to stressful driving situations. However, those who are emotionally stable are dissociated from aggressive driving attributes and therefore would not impact on the driving performance (Milfont and Sibley, 2012).

Dahlen *et al*. (2012) support the hypothesis and thus openness is not associated with aggressive driving behaviours and thus cannot influence wrongful driving performance. Consequently, the personality traits investigated in this study may respond in a similar fashion with regards to the administered conditions (without music, moderate music, loud music).

2.7 EXPERIENCED VERSUS INEXPERIENCED DRIVERS

It is evident that the driving population vary in nature as the law dictates in different countries. For example in the United States of America legal holders of drivers' licenses may be persons over the age of 16, whilst in South Africa a legal driving license is only issued to a person above the age of 18 (Ginsburg *et al*., 2008). It should be noted that age is an indirect proponent of experience, but experience is grossly determined by the skill motorists gain and the ability for one to continuously develop and re-enact those skills. However, studies have indicated that younger drivers with regards to age are more susceptible to traffic accidents compared to older drivers (Andrew and Westerman, 2012). Younger teenage, inexperienced drivers are readily involved in severe motor vehicle crashes by a factor of 10 compared to adult drivers (Deery, 1999; Ginsburg *et al*., 2008). Younger, inexperienced drivers are said to perform inferiorly compared to more experienced drivers with regards to their driving skills (Deery, 1999; Ginsburg *et al*., 2008). The chief problem associated with inexperience versus experience is the drivers' poor hazard perception skills, attention to control the vehicle, time sharing ability and calibration (Lee, 2008). Younger, novice drivers tend to overestimate their driving skills and this is also known as optimism bias (De Craen *et al*., 2011). Inexperienced drivers scan the roads differently compared to more experienced adult drivers, indicating the underdeveloped motor-perception skills in younger novice drivers (Lee, 2008). The underdeveloped motor perception skills has a direct effect on drivers steering and vehicular control (Lee, 2008). In addition to this, inexperienced drivers have a diminished hazard awareness and depend on the focal vision to guide their lateral control as opposed to "all-round control" (Ginsburg *et al*., 2008). Studies have shown that younger novice drivers are unable to attend to the appropriate stimuli at the right amount of time, according to their attention resources, which often leads to an issue of time sharing. For purposes of this study time sharing refers to the switching of attention from the main task while undertaking two or more concurrent tasks (Deery, 1999; Choi *et al*., 2013). With regards to calibration, young inexperienced drivers lack the ability to match their task performance with the task demands necessary to be executed (Deery, 1999). All these aspects indicate the discrepancies faced by inexperienced drivers with regards to their cognitive, visual and motor capabilities. In addition, operating other technological devices while driving and listening to loud music at 90 dBA, may affect the individual's physiological state and mental capacity in motor vehicle control (Ginsburg *et al*., 2008; Lee, 2008; Sinclair, 2013). Discontinuation of driving particularly in older individuals is as a result of visual, cognitive deficits, and/or deterioration of motor capabilities (Ginsburg *et al*., 2008 Hoggarth *et al*., 2010). Effective training is required in order to improve pattern of eye movements so as to apply suitable hazard perception skills (Lee, 2008).

The psychosocial and social constructs play a pivotal role in human conditioning, and and individuals' way of thinking and ideas, perceptions and behavioural outcomes which may be exhibited on the road, such as aggressive driving patterns and/or road rage (Rundmo, 2003; Lee, 2008; Sinclair, 2013). The behavioural driving outcomes have been identified as the most central of the factors within the study of traffic related research and contributing towards 95% of the accident rates (Rundmo, 2003; Zhao *et al*., 2012). Rundmo (2003) has sought to determine the behavioural driving outcomes through the psychological domain, and studies mention that individual differences are directly related to the risk taking behaviour most especially in young inexperienced drivers. Deery (1999) reiterates that younger novice drivers grow accustomed to risky driving styles than older motorists by increasing speed, driving through amber (caution) lights, leaving shorter distances between the car in front of them and many more traffic violations. Although attitudes are difficult to measure Lee (2008) states that attitudes are correlated to risk taking propensity. The literature reviewed here is as a result of the various methods taken to elicit these findings. The next section of this chapter continues to discuss measurements that may assist in answering the anticipated question.

2.8 MEASUREMENTS

The study must use suitable techniques to measure the proposed question. Therefore, the measurements of the auditory modality stimuli against the motorists' driving ability take on the most relevant measures that can best reveal the motorist's driving, performance, psychophysiological responses as well as their subjective perception under this study's methodological procedures. Louw (2013) mentions that the obtaining of measures requires no interference of the driving task itself and as such the accuracy and reliability in testing procedures require controlled parameters.

2.8.1 Driving performance

Driving research over the years has investigated components of performance using different methods. Empirical measures of driving performance show that different studies consider performance components as vehicular control, lane deviation, whether motorists adhere to the traffic rules and regulations, brake responses, visual ability, cognitive ability, physical functionality, driving speed and so on (Cassavaugh and Kramer, 2009; Calvi *et al*., 2012; Choi *et al*., 2013; Casutt *et al*., 2014). Different studies therefore may consider the various components in context to the research objectives. Consequently, in order for researchers to obtain the necessary findings some studies utilise on-road test or simulators (low or high fidelity) for which both techniques have their advantages and short falls in deriving the retorts of the components. Research conducted by Casutt *et al*. (2014) documented the differences between on-road tests and driving simulators. The research found that on-road tests demonstrated weak correlations with regards to the cognitive ability in older motorists and similarly on-road tests fail to enhance traffic safety (Casutt *et al*., 2014). Casutt *et al*. (2014) state that there is a lack of reliable and valid standardized data from on-road assessments on driving performance particularly for older road users and there is a proclivity for studies to favour driving simulators because “driving simulators seem to be a useful alternative to on-road test since they offer the potential to design standardized driving scenarios which are the basis of good measures” as well as the fact that driving simulators propose a component of safety (Casutt *et al*., 2014). On-road tests are said to be associated with minimal experimental control, but maximum real life association which makes on-road test advantageous in this regard. However, driving simulators have more experimental control but minimal real life applicability, which makes it less advantageous (Casutt *et al*., 2014). Isler *et al*. (2011) looked to compare the effect of higher-order driving skill training and more traditional vehicle handling skill training and an untrained control group in relation to on-road driving performance, hazard perception, attitudes to risky driving and driving confidence levels. Isler *et al*. (2011) found that in terms of on-road driving that those who received high-order driving skill training showed a statistically significant improvement pertaining to the visual search variable, composite driving score, hazard perception, safer attitude towards closer following, overtaking and driving confidence. This was found particularly in novice drivers who supposedly may not fully realise the dangers that do exist on the road and also through those with prior training who have an unjustified level of confidence. For the vehicle handling skill training there were significant improvements related to participants' on-road direction control, the speed choice and composite driving score, but this group did not show improvements in their hazard perception, attitudes towards driving or driving confidence. With that said, if the study employed on-road test, cofounding possible issues of the hazard perception may have affected the overall performance and also challenges the safety of the participants. In this context therefore, Isler *et al*. (2011, p. 1825) findings suggest that training of high-order driving skills could provide "a feasible low-risk alternative to on-road experience and delivers similar improvements in visual search." Thus Isler *et al*. (2011) found that the training using laboratory simulation techniques can improve hazard perception and reduce risk behaviour, the skills learnt may possibly be applied to on-road test assessments but the disadvantage however is the fact that there was no evidence of driver confidence. In that case the simulator has far greater use particularly for training inexperienced drivers to improve their driving ability. Simulators are also considered a safer method in evaluating performance variables (Young *et al*., 2008; Brooks *et al*., 2010; Reimer *et al*., 2010).

For this study the driving performance focuses on measuring the tracking deviation and reaction time. Tracking deviation is synonymous to the standard deviation of lane position, and measures the accuracy in which motorists remain on the target line/lane depending on the simulator's design (Jorna, 1992; O'Hanlon *et al*., 1995; Davenne *et al*., 2012). Tracking deviation is one of the most readily used driving performance measures by various authors as it often correlates to findings to fatigue, mental fatigue, concentration, vehicular control, reaction time, alertness etc. in the context of driving (Andrews and Westerman, 2012; Louw 2013, Sunshine, 2013). Therefore tracking deviation depicts the overall major task of "maintaining the safe control of the vehicle under different conditions" (Louw, 2013, p. 24). Vehicular control in this instance requires that participants steer accurately on the target line- the further the 'vehicle' from the target line the less the ability to control the vehicle. Modern day driving simulators provide accurate environmental settings and scenarios, likely to bring forth similar physiological responses as though one were driving in the real world (Brookhuis and Waard, 2010). The reaction time measured (in seconds) is another proponent or variable of the Human Kinetics and Ergonomics simulator and it measures the “effective reaction delay, taking into consideration both the deviation from the middle target line and the amplitude and frequency of the target line” (De Gray Birch, 2012, p.45). The driving simulator measures the response time of participants during each condition, showing differences in the ability for participants to respond to stimuli to tasks. Most studies have investigated simple and complex reaction time looking at the notion of duality between tasks using the dual task paradigms and using a number of theoretical frameworks (Unitary resource theory and/or Multiple resource theory) for instance, to explain dual task interference (visual-auditory) (Vaportzis *et al*., 2013).

2.8.2 Psychophysiological measures

Psychophysiological measures combine both the psychological and physiological aspect and is often used in human factors and ergonomics research and are considered imperative when distinguishing an individual’s bodily responses to varying stimuli when under different degrees of stress whether mental and/or physical (Louw, 2013; Sunshine, 2013). The assessments of psychophysiological measures in participants may provide information on the strain or stresses experienced in the form of tasks which might reflect itself in the physiological changes of respondents (Galy *et al*., 2012). It is therefore important to assess a combination of psychophysiological measures which may give a better overview of the state of the participants. However, it is also important to note that psychophysiological measures may be influenced by a number of variables. These variables therefore may not necessarily indicate the applied strain or stress imposed on participants. According to Galy *et al*. (2012) one of the major advantages of psychophysiological measures is the continuous availability of bodily data. The measures of psychophysiological measures may provide inferences to mental effort which include heart rate, heart rate variability measures, and oculomotor activity, which will be discussed and investigated in this study (Sunshine, 2013).

Physiological measures have long been used to correlate the human behaviour under various workload environments, and as such have demonstrated reliable findings between objective physiological measures as well as self-administered reports. Operators or drivers in this context are likely to exhibit some form of effort in completing the driving task, however voluntary regulation of effort is based on personality traits which involves the phenomenon related to the adaptation of driving behaviour (Brookhuis and Waard, 2010). The validity of physiological measures are consequently due the investigator's ability to accurately use the equipment that tests for physiological measures such as heart rate frequency, heart rate variability, brain activity, and oculomotor measures such as eye movements: pupil dilation, saccades, blink frequency and blink duration. This research therefore only considers a limited number of measurements due to the scope of the study as well as the limitation to the necessary equipment and will therefore examine heart rate frequency, heart rate variability, eye movements: pupil dilation, eye speeds, fixation duration, blink frequency and blink duration.

Psychophysiological measures have been to be linked with measures relating to the following: Alertness, mental concentration, and motivation; reduced work output; and weaker and slower muscular contractions and many more, but this study will focus primarily on the first part of the psychophysiological measures seeing that listening to music while driving has been suggested to affect alertness and mental concentration. Psychophysiological measures have greatly been associated with driving fatigue (Lal and Craig, 2001). It has been found that when one is fatigued one will show a state of a lowered heart rate and a high rate in blink frequency (Brookhuis and Waard, 2010; Galy *et al*., 2012). In driving performance particularly examining issues of monotony, boredom and fatigue while driving require a full scope of measurements. The measurements often look at physiological responses, oculomotor measures subjective measures as well as objective performance of the task - in this instance driving performance measures (Brookhuis and Waard, 2010).

Yamakoshi *et al*. (2009) say that well established strategy uses the Drivers Activation State, which objectively indicates the state of certain physiological control systems. The Driver Activation State is responsible for obtaining information on the level of awareness of the driver (Yamakoshi *et al*., 2009). Yamakoshi *et al*. (2009) mention that there are two ways of addressing monotony when driving and lowered and these include: A development of a biofeedback system in the car: which would detect the physiological signals from the driver, for example blink frequency or ECG-RR intervals, oculomotor measures; however this system would require thorough investigation and revision prior to implementation. The second is the development of bio-feed forward system in the car, which is said to observe monotonous situations when driving; it measures physiological concepts such as cardiovascular parameters (heart rate and heart rate variability), EEG an indirect reflection of brain activity, oculomotor measures and lastly the activation techniques for vibration, arousal, acousmatics etc. (Yamakoshi *et al*., 2009; Brookhuis and Waard, 2010).

Heart Rate Frequency

Heart rate frequency (HRF) and heart rate variability (HRV) measures are used in most scientific disciplines, observing the relationship between a stimulus and how the heart functions or responds to those specific stimuli (Acharya *et al*., 2006; Lin *et al*., 2008). The measures of cardiovascular changes and/or activity have long been cited in literature and some have examined the task demands, physiological responses of stresses i.e. (anxiety, arousal, excitement, mental load and effort) reflexive of the complex patterns of the autonomic system (Kallinen and Ravaja, 2004; Oron-Gilad *et al*., 2008; Sosnowski *et al*., 2010; Fairclough and Roberts, 2011; Galy *et al*., 2012; Sunshine, 2013). The popularity in using these measures is often as a result of the fact that the use of the equipment is unobtrusive, non-invasive and can be used in both laboratory and field settings (Sunshine, 2013). Heart rate frequency and heart rate variability measures are also considered valid and reliable in indicating the complete state of respondents under different conditions. For purposes of the study heart rate is defined as the number of beats that occur within a fixed period of time, often calculated per minute (Fairclough and Roberts, 2011). The heart rate frequency of an individual is said to rise with increase in cognitively demanding tasks and of internal attentional processes, whilst a decrease in heart rate is indicative of external attentional demands (Galy *et al*., 2012; Louw, 2013; Sunshine 2013). An increase in heart rate frequency measure due to the music and intensity of the music listened to for this study may deduce a state of arousal and awakening (De Gray

Birch, 2012). Moreover, Louw (2013) states that the difficulty of a task and distracting conditions are likely to increase the heart rate of an individual and decrease if an individual is relaxed, fatigued or with reduced task difficulty. Whilst listening to music is not a difficult task, for some individuals it may be the same as a distracting condition, which may further induce the activation of the autonomic nervous system, increase heart rate because of the propelled feelings of arousal, anxiety, excitement, sadness and so on, thus imposing on concentration and attention. The research can establish the extent to which different personality traits can cope with listening to music and driving and how it affects driving performance. Cardiovascular parameters such as heart rate are useful in indicating the attention aspects of an individual's mental load and overall state of being (Fairclough and Roberts, 2011).

Heart Rate Variability

The origins of heart rate variability evaluation date back over two hundred and ninety one years ago. Early work of heart rate variability included the monitoring of the heart sounds and rhythms by auscultation, and physicians then noticed that the beat-to-beat rhythm shifts differed with ageing, illnesses, and the physiological state (Berntson *et al*., 1997). According to Berntson *et al*. (1997), the first documented observation of heart rate variability was accredited to Hales (1733) who observed the respiratory pattern, blood pressure and pulse of a horse. Further developments were observed by Ludwig (1847) using a kymograph looking at the regular quickening of pulse rate with inspiration and a slowing with exhalation in a dog. This finding particular finding by Ludwig is said to possibly be the first ever documented report of respiratory sinus arrhythmia (Berntson *et al*., 1997). With the discovery and early work of respiratory sinus arrhythmia, heart rate variability has also been seen as an important mode of measurement as it may be used to analyse diseases such as strokes, Alzheimer, leukaemia, epilepsy, chronic migraines, obstructive sleep apnea and many more (Acharya *et al*., 2006; ChuDuc *et al*., 2013). Continuous assessments of heart rate and heart rate variability have thus led to research that looks to understand the physiological mechanisms that govern heart rate rhythms, the relationship between heart rate variability and clinical status, and lastly the psychological processes and heart rate variability, which this research is mostly interested in (Berntson *et al*., 1997).

Heart rate variability reflects the cardiovascular system as it is influenced by both the parasympathetic and sympathetic branches of the nervous system (Acharya *et al*., 2006; Pattyn *et al*., 2008; Huang *et al*., 2013). Heart rate variability thus changes according to various influences i.e. the difficulty of a task, time on task and physiological state of the individual. The variability of the heart rate therefore "provide[s] information on the functioning of the nervous system's control on the heart rate and its ability to respond to stimuli" (Acharya *et al*., 2006. p.1031). Heart rate variability is the variance between inter-beat-interval of normal heart beats, it is the measure of variability for which inter-beat-intervals is the time between the two beats (Acharya *et al*., 2006; Brookhuis and Waard, 2010; ChuDuc *et al*., 2013; Huang *et al*., 2013). The heart rate variability's usefulness is important as studies have shown that during a sustained attention task the heart rate variability is significantly reduced (Louw, 2013, ChuDuc *et al*., 2013). It has been found that heart rate variability decreases with the increase of task complexity so there is a direct relationship between heart rate variability and function on time of task. A low or decreased heart rate variability is therefore said to be indicative of the functioning of the sympathetic nervous system (ChuDuc *et al*., 2013). Contrary to the reduction of heart rate variability with task difficulty, heart rate variability increases significantly with the reduction of task difficulty; it also indicates diminished alertness and a possible state of fatigue or relaxing of the individual and is associated with the parasympathetic nervous system (Acharya *et al*., 2006; ChuDuc *et al*., 2013).

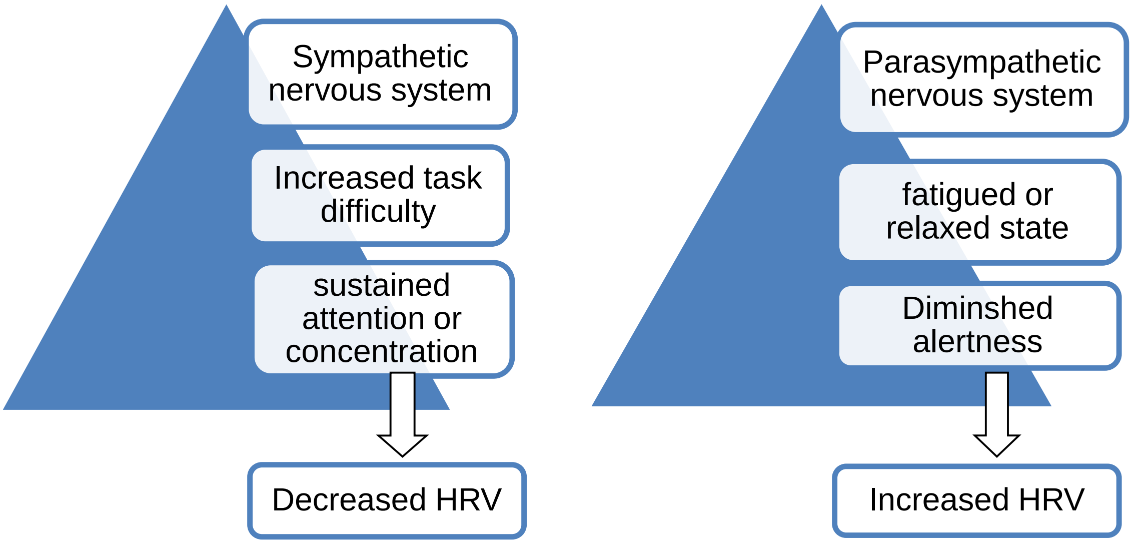

Figure 6: Synopsis of the processes that determines heart rate variability.

Heart rate variability: Analysis methods

Heart rate variability is commonly analysed using three methods aimed at investigating the regulations of the autonomous nervous system and states of being such as the individual's mental workload, memory performance, and attention (ChuDuc *et al*., 2013). These methods of detecting heart rate variability are named as follows: the non-linear, time domain and frequency domain methods (ChuDuc *et al*., 2013). However in most studies the heart rate variability is typically evaluated using the time domain or frequency domain measures (Louw, 2013).

Non-Linear

The cardiovascular system is analysed using a non-linear structure as the cardiovascular system is complicated in nature and thus a linear method of investigation would be fruitless in determining various results related to the human's performance (ChuDuc *et al*., 2013). The non-linear method therefore can detect abnormalities of the heart's rhythm. Trained researchers and/or medical practitioners use this technique and are able to perceive changes in the sympathetic and vagal activity of the heart using a rapid fluctuation concept (ChuDuc *et al*., 2013).

Time Domain Analysis

Time domain analysis of heart rate variability can be calculated into the following variables: The calculation of the intervals between normal hearts beats (N-N), the difference between the shortest and longest normal heart beats in that interval. The other measures differences between intervals of successive normal heart beats. The measure of successive normal to normal heart beat is referred to as the standard deviation of all the normal to normal heart beat intervals (SDNN) and (rMSSD). This gives the total heart rate variability in a specific period of time (Sunshine, 2013; Khor *et al*., 2014). Following this, is the square root of the mean squared differences between successive normal to normal intervals in milliseconds (Sunshine, 2013). According to Sunshine (2013) the measuring of heart rate variability using time domain typically uses two types of variables.

Frequency Domain Analysis

The frequency domain analysis or spectral analysis is quantified into standard frequency domain measurements, denoting three frequency domains for heart rate variability. The power spectral analysis was employed to extract and distinguish parasympathetic and sympathetic influences on cardiovascular control (Fairclough and Houston, 2004). The frequency domain measurements are named as follows: very low frequency ranging between (0.003-0.04 Hz), low frequency (0.04-0.15 Hz) and high frequency (0.15-0.4 Hz) (Huang *et al*., 2013; Sunshine, 2013; Khor *et al*., 2014). Each of the frequency domains reflects neurological events that occur in the parasympathetic and sympathetic activity. A very low frequency reflects a number of factors receiving input from the chemoreceptors, thermo receptors, reninangotensis system and other systems responsible for part of the human body's homeostasis (ChuDuc *et al*., 2013; Huang *et al*., 2013). The low frequency reflects predominately the sympathetic activity, and the high frequency band reflects the functionality of the parasympathetic nervous system as well as the vagus nerve or vagus tone and respiration (Redondo *et al*., 1992; Berntson *et al*., 1997; Acharya *et al*., 2006; ChuDuc *et al*., 2013; Sunshine, 2013).

The frequency bands are normalised and calculated using two parameters, namely power and centre frequency (Sunshine, 2013). Power frequency is defined as the total power within a respective frequency band in (ms^2) and centre frequency is the "frequency splitting the power spectrum of respective frequency band into two portions of equal power" (Sunshine, 2013, p, 21). The frequency band is often read in the Low Frequency to High Frequency ratios (LF:HF) (Patel *et al*., 2011). Essentially the LF:HF ratio is commonly used to demonstrate the balance between compensatory control mechanisms and other activity occurring during specific events (Kahneman, 1973; Hockey, 1997). According to Louw (2013) the LF:HF ratio is considered to be a measure of sympathovagal balance and therefore a decrease in heart rate variability measures of the frequency bands are related to a more drowsy state, while increases specify greater mental workload or alertness (Patel *et al*., 2011; Louw, 2013). Louw (2013) concludes therefore that the decrease and increase in the LF:HF ratio are linked with parasympathetic and sympathetic dominance, respectively. While there is strong evidence for the mediating factors for both HF and LF (when combined with LF:HF ratio), "the physiological correlates of ultra-low frequency (ULF) and very low frequency (VLF) components are still largely unknown" (Louw, 2013, p. 28). Hence, these frequencies do not hold any importance when HRV is analysed in 5-minute intervals (Louw, 2013, p. 28), as is the case in the existing study. Patel *et al. (*2011) therefore conclude that analysis of the LF and HF bands along with the derivation of LF:HF ratio, can provide sufficient and accurate information regarding the extent and physiological state throughout testing, more especially fatigue. To reiterate heart rate and heart rate variability is imperative in studies of this magnitude as they have the ability to detect unwarranted cardiovascular activity as well as physiological state of patients during different states or activities. Therefore, this study is likely to indicate an individual with lowered LF:HF ratio during the first 30 minutes of a driving task and when music administered may have an opposite effect on LF:HF ratio.

Whilst there are relatively few studies focusing on personality traits and driving task as well as heart rate variability Huang *et al*. (2013) state that there is a noticeable negative correlation between HF power and anxiety traits, neuroticism, and harm avoidance. The study looked at investigating fatigability and heart rate variability in health subjects. The study intended to investigate whether a correlation existed between the personality traits and autonomic nervous system functioning (Huang *et al*., 2013).

This study is worthy of further investigation as it paves the way to analysing individuals' fatigability states against heart rate variability and the extent to which different personality traits are able to predict the effect listening to music has on heart rate variability, state of being and impact on driving performance. Huang *et al*. (2013) found that there is a correlation between autonomic nervous system and personality features. It was found that the HF is negatively correlated with harm avoidance. In addition to this Huang *et al*. (2013) found that the sub-dimensions of harm avoidance (fatigability and asthenia) illustrate the greatest negative correlation especially in male subjects with heart rate variability whilst the LF shows a high positive correlation with exploratory excitability in males (Huang *et al*., 2013). Exploratory excitability is the tendency to explore interesting and exciting stimuli (Huang *et al*., 2013). Lastly fatigability is correlated with HF power and positively correlated with LF, which indicates that high fatigability is parallel with a pattern of high sympathetic tone and low vagal tone. Therefore negative feedback experienced by drivers while completing the monotonous driving task would reduce the effort and therefore decreases motivation towards completing the task. This may be readily seen in extraverted individuals more than introverts.

Oculomotor measures

The combination of various oculomotor measures such as facial muscle tone; provides information on effort, emotional and physical strain (Brookhuis and Waard, 2010). Recent technology has provided researchers with the ability to detect eyelid activity and eye motion activity using specific equipment (Azim *et al*., 2014). For example, video-based score equipment may detect and score the percentage of closure (PERCLOS) of the eyelid on a minute-to-minute basis and blink frequency (Azim *et al*., 2014; Brookhuis and Waard, 2010). The authors found that slow eyelid closure is correlated to a participant's self-rated scores on sleepiness and the equipment has been used to distinguish fatigue-induced attention lapses during a task (Brookhuis and Waard, 2010). However, caution with eye equipment systems are emphasised as the eyes are difficult to detect if there is varying light conditions or vibrations experienced in real driving situations (Azim *et al*., 2014). In addition eye motion activity can be detected using the eye tracker that comprises of a head unit, receiver and recorder (Robertson, 2009). The eye camera facing the pupil of an individual's eye identifies the pupil of the eye, and the pupil size thereof (Goble, 2012). It may analyse other eye movements known as the pupil diameter, eye speeds, fixation duration, saccadic speed and saccadic amplitude, blink frequency and blink duration (Goble, 2012).

Pupil diameter

The pupil diameter was measured to observe fluctuations of the pupil size (measured by the area) of the Dikablis eye tracker system (De Gray Birch, 2012; Goble, 2013). As mentioned previously the pupil size of participants is an inordinate indicator to determine the relationship between the pupil size and increased mental workload (Lin *et al*., 2008). Eye tracking technology has proven to be a useful component to use in its ability to ascertain cognitive activity between tasks and task demand (De Gray Birch, 2012; Goble, 2012; Marshall, 2000). This is best described as the pupil dilating and constricting when an individual is experiencing various mental workloads and other peripheral issues that may be triggered by a state of arousal or sensation-seeking. Wickens (1984) emphasises that pupillary measures are susceptible to the variations in emotional arousal as it is associated with the autonomic nervous system (Wickens, 1984; De Gray Birch, 2012). It is anticipated that the variations in emotional arousal may further be perpetuated by the choice of song played and listened to during the moderately loud music and loud music conditions (Brodsky, 2012). It is therefore considered appropriate to analyse the pupil diameter of the participants during each condition as the pupil diameter may affect the basal or tonic pupil diameter rather than the phasic pupil changes differently for each participant and during each condition. This measurement may possibly give an indication towards the mental workload of the participant's personality trait whether the participant's experience reduced or improved driving performance due to this increase in mental workload as per different music intensity (De Gray Birch, 2012; Galy *et al*., 2012).

Saccades

The saccades of the eye movement refer to the rapid and ballistic eye movements that occur between fixations (Lin *et al*., 2008). Scientifically it has been found that the saccades after the latency lasts for 200-250 ms following a change in the position the eyes had fixated upon initially (De Gray Birch, 2012). For eyes to move together, it requires the control of the amplitude and the direction in which the eyes are moving. Therefore, the main saccadic sequence that occurs comprises of the saccadic amplitude, duration, and velocity (Galley, 1998; De Gray Birch, 2012; Goble 2013). The sequence reveals a relationship between and of the saccadic attributes, with saccades amplitudes having a strong relationship with the velocity and other literature showing a relationship between duration and velocity (Galley, 1998; De Gray Birch, 2012).

For purposes of the study the sequences attributes will be described briefly to facilitate and strengthen understanding of the concepts. The role of saccadic amplitudes refers to the distance between various saccades; the amplitude determines the accuracy of the saccade (Goble, 2012). Whilst the saccadic duration refers to the time taken to complete a saccade, saccade velocity is the speed at which the amplitude is covered, for which eye speeds thus make part of the saccadic velocity and is measured in this study (Goble, 2012). All three concepts (amplitude, duration and velocity) illustrate a relationship between each other that depicts the saccadic main sequence (Galley, 1998). 1998). According to Ryabchikova *et al.* (2009) and De Gray Birch (2012) saccadic movements accompany cognitive processes or activity such as attention, memory and thinking**.** Ryabchikova *et al*. (2009) further state that the cognitive process which is psychophysiological in nature and saccadic eye movements, neurological are closely related and are attributed to the functional and anatomical overlap of the brain pathways and structure which enable planning, programming, and decision making on the one hand, and regulation of saccade generation on the other. Therefore, the saccadic activity can reflect dynamic processes in the brain in order to evaluate various forms of cognitive activity (Ryabchikova *et al*., 2009). According to De Gray Birch (2012) the peak velocity can be influenced by factors such as the complexity of the task, the time on task and the presence of a secondary task or the state of a mental task in a visual performance task. Moreover, the changes in the saccadic velocity may be attributed to the natural fluctuations in alertness, vigilance, mental workload and/or mental fatigue (De Gray Birch, 2012). Thus, in this study the saccadic velocity in the form of eye speeds will be analysed to deduce the attention and mental workload during the proposed task.

Fixation Duration

Eye movements are essential as they provide important information about the location of attention, the nature and sequence in which the eyes move in accordance to the cognitive operations occurring (Lin *et al*., 2008). Fixation duration refers to the amount of time the eyes of an individual remain fixed on a specific object or stimuli prior the ignition of saccades (Rayner, 1998). Chaplin (2010) found a correlation between the duration of fixations and the fatigue state of a human being. The study may therefore employ the same eye-movement techniques in order to identify the fatigue state of the individual during a monotonous driving performance task as well as mental workload. According to Lin *et al*. (2008), it has been found that the duration of fixations are predominately related to the difficulty or ease of the displayed processes and task at hand.

Blink frequency and duration

Blink frequency and duration is the number of times the eyelids close in one minute, the number of blinks that occur in that time is called the blink duration (Roche and King, 2010). Blink frequency and duration often also indicate alertness and fatigue/tiredness of the participants (Schleicher *et al*., 2008). The slower the blink per minute this indicates signs of tiredness and fatigue (Schleicher *et al*., 2008).

Other Psychophysiological measures

Brain activity

The use of examining brain activity helps establish an individual's wakefulness or sleepiness (Brookhuis and Waard, 2010). The analysing of brain activity requires advance AgAgcl-electrodes that are placed on participants' scalps and detects the background activity of electroencephalogram (EEG) as well as event related potential (Brookhuis and Waard, 2010). Electroencephalogram is the collection of low-voltage oscillations between 1 Hz and 30 Hz which indicates the functioning of the brain and in the same breath this can be correlated to the an individual's state of being. The event related potential is the "transient series of voltage oscillations in the brain, to be discriminated from the background EEG" (Brookhuis and Waard, 2010, p. 900). The low-voltage oscillations are sub-divided into categories illustrating a different part of the brain activity, namely 1-5 HZ is called the delta waves, 5-8 Hz are the thetha waves, 8-12 Hz alpha waves, and 12 Hz and above the beta waves. According to Brooks and Waard (2010) these waves indicate the alertness of the individual as well as detect the vigilance condition of the drivers while completing a specific driving task in long distance driving and monotonous roads (Larue *et al*., 2011). An individual whose delta waves are predominately activated will illustrate various phases in actual sleep, whilst alpha waves show drowsiness and thetha waves prompts one to sleep the beta waves show general alertness and wakefulness (Brookhuis and Waard, 2010). This type of information provides scientists with necessary tools and methods of possible counter-measures in alleviating unwarranted sleepiness or fatigue during a task.

The event related potential components have been said to reflect distinct perceptual, cognitive and motor processes useful in providing information that allows analysis of the decomposition of the processing requirement in complex task situations (Brookhuis and Waard, 2010). Overall the measures of brain activity are essential in exemplifying the human cognitive functioning and processing while completing a task. Knowledge of this magnitude highlights the vast scope in improving human-to machine and task relationship. This provides ways in which scientists may advance worker capability or driving performance with less strain on human integrity (Brooks and Waard, 2010).

2.8.3 Subjective measures

Drivers rating their driving perceptions such as crash involvement, accidents, risks and/or performance dates back from the work of Finns and Bragg (1986) and similar work was replicated by Matthews and Moran's (1986). The research aimed to assess the significant use of subjective measures, such that in some instances subjective findings and/or perceptions show possible indirect effects (Groeger and Brown, 1989). The research findings showed that the subjective findings of younger drivers versus older drivers; differed, such that younger drivers felt that they were more likely to be involved in accidents, therefore overestimating accident risk greater than older motorists. Other studies show that subjective measures allow for the correlation of information and to provide a holistic interpretation of overall findings i.e. objective driving performance, associated risk, recklessness, dissociations of driving, competitiveness, anticipation etc. (Groeger and Brown, 1989). However, the use of subjective measures needs to be utilised and interpreted with caution because the subjective measures may not necessarily add importance to the objective findings. Employing subjective measures is a practice that has since been adopted in driving research as it is has been a method to identify indirect findings that the objective findings otherwise would not have found. Horberry *et al*. (2006) describe perceived workload subjective measure by comparing two in-vehicle distractions using the phone and entertainment task while driving, where the perceived workload differed across the scenarios. The subjective measured increased significantly compared to a non-distraction while in a driving condition and therefore there was a main statistical significance with in-vehicle distraction (Horberry *et al.*, 2006). Horberry *et al*. (2006) found that the subjective workload was higher for the entertainment task compared to the phone conversation distracter condition. Horberry *et al*. (2016) further mention that the NASA-TLX of the six subscales follow a similar pattern showing that there was a significant main effect for all six subscales with the highest ratings for the entertainment system distracter and lowest rating for the no distraction condition. Mitsopoulous-Rubens *et al*. (2011) however, found no-significant differences in the driving performance and subjective workload measures in the baseline lane change test and so this illustrates how subjective measures may not illustrate precise findings in relation to driving performance research.

Multidimensional driving style inventory (MDSI)

The Multidimensional driving style inventory was particularly developed by Taubmen-Ben-Ari *et al*. (2004) and this measure looked at the assessing motorists' driving styles. The final scale consisted of 44 items and the main point of the scale was to denote driving styles with personality traits. The scale found correlations with the driving styles and the personality traits. For example, self-esteem was significantly and positively associated with careful and patient driving styles (Taubmen Ben-Ari *et al*., 2004).

NASA-Task Load Index

The NASA-Task Load Index (NASA-TLX) is predominately utilised in understanding subjective feelings of workload ratings and perhaps other components like fatigue, which wasn't the primary observation for this study (De Gray Birch, 2012; Galy *et al*., 2012; Ikuma *et al*., 2014). Ikuma *et al*. (2014, p. 458) however, also used the Subjective Workload Analysis Tool (SWAT), which is considered simpler than the NASA-TLX, however, the NASA-TLX is the preferred subjective workload tool, based on the fact that it uses more dimensions as well as provide "a more complete understanding of workload components." De Gray Birch (2012) makes comparisons among various subjective workload tools and highlights the similarities and/or differences between these tools. De Gray Birch (2012) states that research conducted by Rubio *et al.* (2004) is more inclined towards the use of the Workload Profile (WP). However, due to the lack of information in the application and validity of the Workload Profile scale, the NASA-TLX was considered the optimum scale to use simply because the NASA-TLX is well researched and because of the ease of use of the scale (De Gray Birch, 2012). The multi-dimensional subjective workload consists of six subscales to assess mental workload, namely mental demand, physical demand, temporal demand, performance, effort and frustration (Galy *et al*., 2012; Ikuma *et al*., 2014). The first part consisted of fifteen pairwise comparisons representing every possible pairing of the six dimensions (De Gray Birch, 2012; Ikuma *et al*., 2014). Each participant needs to circle the member of each pair that s/he believes or felt would contribute the most during the test session (see Appendix C2) under the heading NASA-TLX Load Index pair comparisons of dimensions. As mentioned by De Gray Birch (2012) the second part of the scale requires participants to complete ratings for the dimensions are obtained through twenty-step bipolar scales, and a score of 0-100 is obtained for each (De Gray Birch, 2012; Rubio *et al.,* 2004) (Appendix C2). The scores are then calculated by means of weighted and unweighted scores, by taking note of the paired comparisons and the rating score, and calculating the adjusted rating score by multiplying the two, and adding the values calculating the total sum of each of the dimensions (mental demand, physical demand, temporal demand, performance, effort and frustration). It is important to note that the subjective measurement of fatigue was not the main objective of this study; the scale was mainly used to provide insight into mental workload demands and to possibly assist with interpretation of the performance and physiological results obtained. In order to obtain the best results the study will give a detailed account on the characteristics of the participants who can take part in the study.

2.9 MEDICAL CONDITIONS THAT MIGHT INFLUENCE DRIVING PERFORMANCE

In driving research a critical factor in obtaining valid and reliable results is in the coverage of identifying medical conditions that may affect the legitimacy of the findings when testing potential participants. Epilepsy, sleeping disorders, Attention Deficit Hyperactivity Disorder (ADHD) and other similar disorders and sensory infirmities might affect driving performance. Individuals with epilepsy may experience uncontrolled seizures which may impair motor, visual, cognitive ability and a loss of consciousness, which may potentially impair driving performance (Yang *et al*., 2010; Crizzle *et al*., 2012).

Yang *et al*. (2010) conducted a study that investigated epileptic patients through the use of computer-based tasks. These included the use of: (a) rFactor, driving simulator game, (b) SNIP, open source generic version of Tetris, and lastly the Frets on Fire, open source generic version of Guitar and Hero, of particular interest were the results found pertaining to epilepsy and driving ability. All the patients who took part in the study had epilepsy that was defined by the International League Against Epilepsy criteria. The study found that driving ability was impaired depending on the seizure type, as they differed in magnitude and character (Yang *et al*., 2010). Driving impairment was analysed in the form of position of the steering wheel from left to right (-1 to +1), velocity, vehicle position, throttle, and timing of the collisions (Yang *et al*., 2010). It was found that participants categorised to have secondarily generalised seizures were next to illustrate the worst driving impairment. All the participants with secondarily generalised seizures encountered some driving impairment during the study (Yang *et al*., 2010). Seventy-five percent of the partial seizures participants were next to illustrate driving impairment, and fifty-percent (50%) of absence seizures met the objective for the criteria with regards to driving impairment. Lastly those with experienced seizures preceded by auras were less likely to cause a collision than those not preceded by auras (Yang *et al*., 2010). The Yang *et al*. (2010) study concluded that driving impairment was found in some but not all patients with partial and absence seizures, and none in auras due to technical errors that occurred during the testing (Yang *et al*., 2010). Although the data of Yang *et al*. (2010) showed that some partial seizures and absence seizures types did not have a significant impact on driving performance, in reality it would be unorthodox to conclude that these seizure types do not have a significant impact in driving performance, posing a threat to the drivers, other motorists and pedestrians.

According to Smolensky *et al*. (2011) the average sleep duration for healthy adults is approximately 7 hours. With the current state of economic and social affairs Smolensky *et al*. (2011) found that the average American adult sleeps far less than the proposed time, and thus respondents who had poor sleeping patterns reported feelings of tiredness, fatigue and the respondents said they perform ineffectively and others mentioned that they drive drowsily during the day time as a result of inadequate amount of sleep. Epidemiological studies have indicated that “sleep-related crashes represent 20% of the traffic accidents in industrial societies, and driving drowsily has been identified as the major explanation of fatal road crashes” (Smolensky *et al*., 2011, p. 534). Smolensky *et al*. (2011) state that sleep disorders are the most common source of day time sleepiness and fatigue.

Reimer *et al*. (2010) mention that inattention has long been considered as a factor in automobile near crashes and accidents. Reimer *et al*. (2010) explored the impact secondary cognitive tasks on individuals with and without attention deficit hyperactivity disorder (ADHD) has on driving ability. The findings illustrated that individuals with ADHD are more likely than and twice as high to suffer from simulator sickness as controls. Furthermore the participants with ADHD impair driving performance. Rosenbloom and Wultz (2011) agree that drivers with ADHD are prone to making more driving *faults* as compared to drivers without ADHD. Literature by

Reimer *et al*. (2010) and Rosenbloom and Wultz (2011) state that drivers with ADHD may have difficulty with regulating attention between driving and secondary tasks. What is of particular interest is the fact that Reimer *et al*. (2010, p. 849) mention "that drivers with ADHD have greater difficulty performing adequately in situations where the primary driving task does not seemingly demand a high level of attention." Seeing that this study demands a low level of attention ADHD participants may be prone to making more driving errors than the participants without ADHD (Reimer *et al*., 2010).

Sensory-motor infirmities like partial deafness itself, and other hearing loss problems may yield invalid results pertaining to the motorists driving performance with the association of listening to an auditory stimulus while driving (Thorslund *et al*. 2013). Literature by Thorslund *et al*. (2013) investigated the effect of cognitive workload among participants with and without hearing loss problems under three driving conditions (Baseline driving, Critical event with a need to act fast, and lastly a Parked car event), and a secondary task to recall four visually displayed letters during the drive was also administered. The main findings of this study indicated that there was no significant difference in driving behaviour and driving performance between Hearing loss participants and normal hearing participants at Baseline driving with no critical event that occurred, both during the secondary task and at the parked car event. However differences in driving behaviour and task performance were found with the complexity and difficulty of the driving task in hearing loss participants compared to normal hearing participants in reducing speeds during the critical events and lack of focus with recalling the four letters displayed (Thorslund *et al*., 2013). Despite the use of low-fidelity simulator and baseline driving in this study, it can be assumed that participants with hearing loss issues will respond poorly to the music listened to while driving and thus the driving performance may be affected as the perception of sound for a participant with hearing loss problems will differ from that of a normal hearing participant (Thorslund *et al*., 2013).

CHAPTER III

3. METHODOLOGY

3.1 RESEARCH CONCEPT

While there are several studies on the effect of music on driving performance and the effect of personality traits on driving behaviour and driving performance (Furnham *et al*., 1999; Rundmo, 2003; Adrien *et al*., 2011; Dahlen *et al*., 2012; Niculită, 2013), very few studies look at all the Big-Five personality traits of individuals and the studies only investigate one or two of the personality traits in conjunction with listening to music while driving and responses thereof (McCown *et al*., 1997; Wiesenthal *et al*., 2003; Taubman-Ben-Ari *et al*., 2004; Ünal *et al*., 2012;). In addition to this, while fatigue does not form the central point of focus for this study, it is important to mention that a number of studies have proved the effect fatigue has on driving ability and that listening to music while driving is considered as the most useful coping mechanism in combatting some of the aspects associated with fatigue (monotony, boredom, boredom proneness, sleepiness) and/or fatigue itself (Brodsky, 2001). Yet, the results are inconclusive in that regard as different personalities have different ability in performance. To test the prediction that listening to music while driving will differ for different personality traits during a prolonged driving protocol, the study had all participants taking part in three conditions, with the one as the control condition and the other two-music conditions at different intensities. In this context tracking performance may correspond with concepts of resource allocation and information processing capacity. This study foresees that listening to music while completing a continuous assessment would influence resource allocation and information processing systems (Louw, 2013). The objective of the project was to understand whether the difference in driving performance and psychophysiological measures between the conditions will differ for different personality traits while being exposed to different music conditions at different intensities.

A low-fidelity driving simulator was utilised to provide a controllable, repeatable and safe environment as compared to a real road situation (Young *et al*., 2008; Brooks *et al*., 2010; Reimer *et al*., 2010). Moreover the simulator was used to measure the driving performance of the participants. Driving performance in this instance is measured as tracking deviation and reaction time. Participants were expected to perform a tracking task on the low-fidelity driving simulator. This is a continuous performance measure and the participants ought to perform at their upper most performance limit for the conditions.

Twenty-five female and male participants took part in the study; sixteen of the participants were female and nine male participants. Using an online Big-Five Inventory scale the personality traits of the twenty-five participants were assessed (extraversion, agreeableness, conscientiousness, neuroticism, and openness) http://personalitytesting.info/tests/BIG5.php (Taubman-Ben-Ari *et al*., 2004). All the different personality groups were subjected to complete three conditions in a randomised order without music condition, the moderately loud music and loud music condition. The music listened to by the participants may either negatively or positively influence driving performance and psychophysiological measures of the participants. Thus, while the participants participated in the three conditions, changes in psychophysiological and driving performance parameters throughout the testing period were investigated.

A once-off measure of the Multidimensional Driving Style Inventory scale were administered, while post-tests of the Perceived Control scale and NASA-TLX were administered in order to account for the participants' perception mental workload after the conditions, and whether the subjective measures may enhance and corroborate the objective laboratory measures (driving performance and psychophysiological measures). Self-report measures in this regard are crucial in order to supplement the driving simulation data obtained (Reimer *et al*., 2010). The impact of the without and with music conditions on the different personality traits was tested using a repeated measures design and a between group design with respect to the personality traits. It must be noted that the study looked at the averages over the prolonged driving conditions, informing on the aspect of fatigue that needs to be counteracted in order to continue the drive thus the participants were required to drive for 45 minutes for each condition (Brodsky and Kizner, 2012).

3.2 HYPOTHESES AND STATISTICAL HYPOTHESES

The purpose of this research was to investigate whether any differences occur in the driving performance parameters, psychophysiological as a result of different music conditions and whether these will differ for different personality traits. The Multidimensional Driving Style Inventory measure was administered once-off before the test to establish the participants' driving style, whilst the NASA-TLX scale and the Perceived Control scale were administered as subjective measures after the different music conditions.

Driving Performance, Psychophysiological Measures and Subjective Measures

1. *Effect of condition*

Null Hypothesis: The hypothesis states that there will be no difference in driving performance, psychophysiological measures and subjective measures between the conditions without music (WM), with moderate music (MM) and with loud music (LM) while driving.

Condition: $H_{o\text{ (WITHOUT MUSIC, MODERATE MUSIC, LOUD MUSIC)}}$: $\mu_{\text{driving performance, psychophysiological measures and subjective measures (WM)}} = \mu_{\text{driving performance, psychophysiological measures and subjective measures (MM)}} = \mu_{\text{driving performance, psychophysiological measures and subjective measures (LM)}}$.

$H_{o\text{, cond, driving perf}}$: $\mu_{\text{driving performance (WM)}} = \mu_{\text{driving performance (MM)}} = \mu_{\text{driving performance (LM)}}$.

$H_{o\text{, cond, psychophy}}$: $\mu_{\text{psychophysiological measures (WM)}} = \mu_{\text{psychophysiological measures (MM)}} = \mu_{\text{psychophysiological measures (LM)}}$.

$H_{o\text{, cond, subj}}$: $\mu_{\text{subjective measures (WM)}} = \mu_{\text{subjective measures (WM)}} = \mu_{\text{subjective measures (LM)}}$.

Alternate Hypothesis: The alternate hypothesis states there is a significant difference in driving performance, psychophysiological measures and subjective measures between the conditions without music (WM), with moderate music (MM), with loud music (LM).

Condition: H_a (WITHOUT MUSIC, MODERATE MUSIC, LOUD MUSIC): μ driving performance, psychophysiological measures and subjective measures (WM) $\neq$ μ driving performance, psychophysiological measures and subjective measures (MM) $\neq$ μ driving performance, psychophysiological measures and subjective measures (LM).

$H_{a, \text{cond, driving perf}}$: μ driving performance (WM) $\neq$ μ driving performance (WM) $\neq$ μ driving performance (LM).

$H_{a, \text{cond, psychophy}}$: μ psychophysiological measures (WM) $\neq$ μ psychophysiological measures (MM) $\neq$ μ psychpysiological measures (LM).

$H_{a, \text{cond, subj}}$: μ subjective measures (WM) $\neq$ μ subjective measures (MM) $\neq$ μ subjective measures (LM).

2. *Effect of personality*

Null Hypothesis: The second hypothesis states that there will be no difference between driving performance, psychophysiological measures and subjective measures between different personality traits (extraversion, agreeableness, conscientiousness, neuroticism, and openness) while driving.

Personality: H_o (driving performance, psychophysiological measures and subjective measures):
μ Extraversion $=$ μ Agreeableness $=$ μ Conscientiousness $=$ μ Neuroticism $=$ μ Openness.

Alternate Hypothesis: There is a difference between driving performance, psychophysiological measures, and subjective measures between different personality traits while driving.

Personality: H_a (driving performance, psychophysiological measures and subjective measures):
μ Extraversion $\neq$ μ Agreeableness $\neq$ μ Conscientiousness $\neq$ μ Neuroticism $\neq$ μ Openness.

3. *Interactional effect between condition and personality*

Null Hypothesis: The hypothesis states that there will be no interactional effect between conditions and personality traits with respect to driving performance, psychophysiological measures and subjective measures.

Condition, Personality: H_o (driving performance, psychophysiological measures and subjective measures):

$$\mu_{WM, EX} = \mu_{WM, AG} = \mu_{WM, CO} = \mu_{WM, NE} = \mu_{WM, OP}$$

$$= \mu_{MM, EX} = \mu_{MM, AG} = \mu_{MM, CO} = \mu_{MM, NE} = \mu_{MM, OP}$$

$$= \mu_{LM, EX} = \mu_{LM, AG} = \mu_{LM, CO} = \mu_{LM, NE} = \mu_{LM, OP}$$

Alternate Hypothesis related to personality traits: There will be an interactional effect between conditions and personality traits with respect to driving performance, psychophysiological measures and subjective measures.

Condition, Personality: H_a (driving performance, psychophysiological measures and subjective measures):

$$\mu_{WM, EX} \neq \mu_{WM, AG} \neq \mu_{WM, CO} \neq \mu_{WM, NE} \neq \mu_{WM, OP}$$

$$\neq \mu_{MM, EX} \neq \mu_{MM, AG} \neq \mu_{MM, CO} \neq \mu_{MM, NE} \neq \mu_{MM, OP}$$

$$\neq \mu_{LM, EX} \neq \mu_{LM, AG} \neq \mu_{LM, CO} \neq \mu_{LM, NE} \neq \mu_{LM, OP}$$

3.2.1 Subjective Measures

As subjective measures are not recorded continuously but before and after the condition, the following conditions are concerned with the possible difference in subjective response before and after the testing conditions.

4. *Effect of timing*

Null hypothesis: There will be no difference in subjective measures between conditions with respect to time on task effect.

Timing: H_o (WITHOUT MUSIC, MODERATE MUSIC, LOUD MUSIC): μ subjective measures (WM) $=$ μ subjective measures (MM) $=$ μ subjective measures (LM).

Alternative Hypothesis: There will be a difference in subjective measures between conditions with respect to time on task effect.

Timing: H_a (WITHOUT MUSIC, MODERATE MUSIC, LOUD MUSIC): μ subjective measures (WM) $\neq$ μ subjective measures (MM) $\neq$ μ subjective measures (LM).

5. *Interactional effect between condition and personality*

Null Hypothesis: The hypothesis states that there will be no interactional effect between condition and personality traits with respect to subjective measures.

Condition, Personality: $H_{o\text{ (subjective measures)}}$: Δ=post-test

$$\Delta_{WM, EX} = \Delta_{WM, AG} = \Delta_{WM, CO} = \Delta_{WM, NE} = \Delta_{WM, OP}$$

$$= \Delta_{MM, EX} = \Delta_{MM, AG} = \Delta_{MM, CO} = \Delta_{MM, NE} = \Delta_{MM, OP}$$

$$= \Delta_{LM, EX} = \Delta_{LM, AG} = \Delta_{LM, CO} = \Delta_{LM, NE} = \Delta_{LM, OP}$$

Alternate Hypothesis: There will be an interactional effect between condition and personality traits in subjective measures.

Condition, Personality: $H_{a\text{ (subjective measures)}}$:

$$\Delta_{WM, EX} \neq {}_{WM, AG} \neq {}_{WM, CO} \neq {}_{WM, NE} \neq {}_{WM, OP}$$

$$\neq \Delta_{MM, EX} \neq \Delta_{MM, AG} \neq \Delta_{MM, CO} \neq \Delta_{MM, NE} \Delta \neq {}_{MM, OP}$$

$$\neq \Delta_{LM, EX} \neq \Delta_{LM, AG} \neq \Delta_{LM, CO} \neq \Delta_{LM, NE} \neq \Delta_{LM, OP}$$

6. *Interactional effect between condition and time effect*

Null hypothesis: There will be no interactional effect between the condition and time effect with respect to subjective measures.

Condition, Timing: $H_{o\text{ (subjective measures)}}$: Δ=post-test

$\mu\Delta_{WM} = \mu\Delta_{MM} = \mu\Delta_{LM}$

Alternate hypothesis: There will be no interactional effect between the condition and time effect with respect to subjective measures.

Condition, Timing: $H_{a\text{ (subjective measures)}}$:

$\mu\Delta_{WM} \neq \mu\Delta_{MM} \neq \mu\Delta_{LM}$

3.2.1.2 Task goal

The driving simulator for the driving task presented a curved road and the yellow triangle is representative of the vehicle's bonnet. All participants must assume eligible driving skills and attention when completing the task throughout the 45 minute driving protocol, as it is required of them to drive as accurately as possible on the middle white line that separates the two lanes, using the tip of the yellow triangle (Figure 7). The driving task does not change throughout the three conditions for all participants.

3.2.1.3 Task Duration

Different simulator studies have shown fatigue effects and performance decrements as early as 20-25 minutes into the drive, while other studies observed significant differences after 40 minutes into a driving protocol or 90 minutes (Thiffault et al., 2003; Ting *et al*., 2008; De Gray Birch, 2012, Louw, 2013). Literature conducted by Reimer *et al*. (2010) showed that participants drove for 35 miles which is equivalent to 50 minutes of a drive. Differences observed with simulator test times, may be due to the differences in the build and design of the simulator, the interface experience participants have with the simulator, issues participants are confronted with like simulator sickness, which impede participants from completing the task. Therefore, through explorative studies a 45 minute protocol was considered a suitable time to simulate a realistic long duration drive likely to induce facets of fatigue such as monotony, boredom and to see the differences between the conditions as the without music condition acts as a control for the two music conditions.

Driving performance indicators

- The variables of interest in this regard would be the tracking deviation is calculated as the average deviation from the middle white line (target line) in metres (Göbel *et al*., 2008). The further away the yellow triangle is from the target line the 'worse' the deviation, and the closer the triangle is from the target line the less the deviation (Göbel *et al*., 2008).

- Reaction time produces the effective reaction delay (in seconds). This parameter is independent of the driving speed and curvature of the target line. It takes into account the calculation of the deviation to the target line and the amplitude and frequency of the target line (Göbel *et al*., 2008).

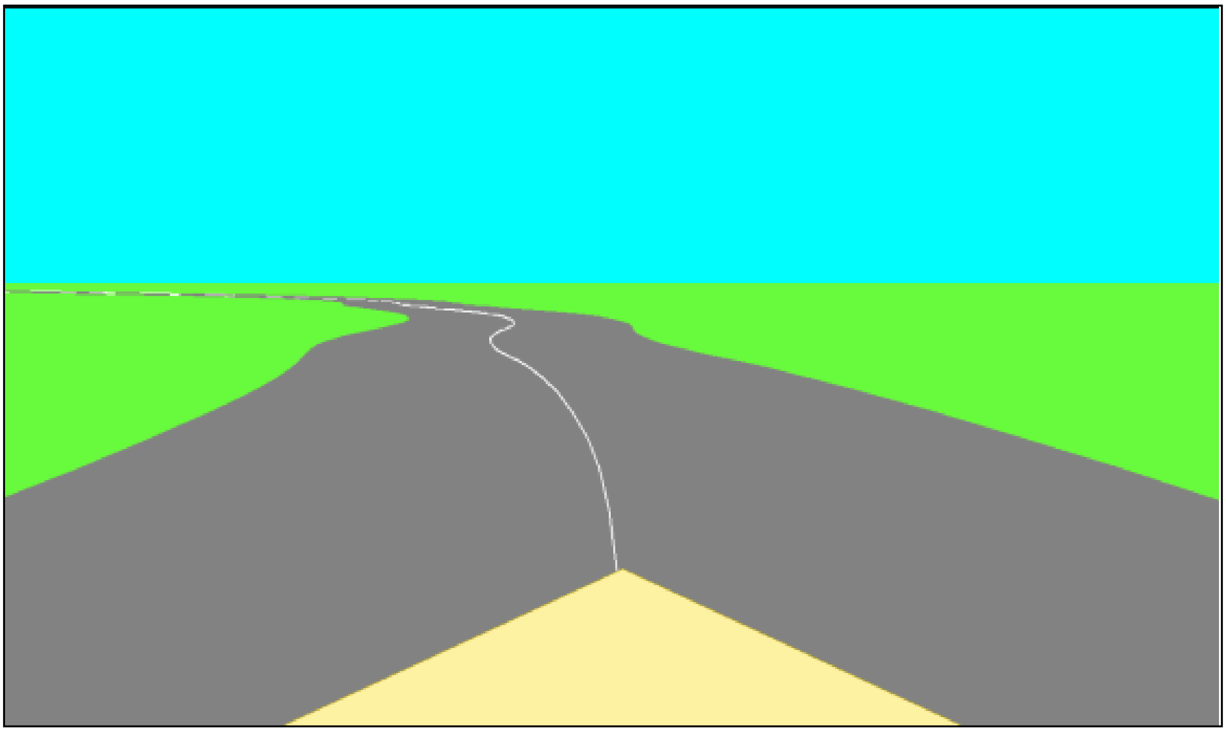

Figure 7: simulator scene

3.3 CONDITIONS

The participants were required to drive for 45 minutes under the three conditions with respect to music (Brodsky and Kizner, 2012). The without music condition required that participants drive in complete silence, the moderately loud music condition required participants to listen to music while driving at a range of 55-65 dBA and thrirdly participants were required to drive and listen to music at a loud intensity of 75-85 dBA. Literature by Brodsky (2001) and Brodsky (2002) indicate that moderate-intensity ranged between 50-65 dBA. The third and final condition named loud music condition would be played at an intensity of 75-85 dBA as used in studies by (Brodsky, 2001; Ünal *et al*., 2013). It should be noted that a range is given, seeing that music has its own frequencies and tends to vary within a song. All these conditions were assessed according to the five personality traits (extraversion, agreeableness, conscientiousness, neuroticism, and openness) to determine whether any of these groups react either positively or negatively under the different music conditions and whether this will negatively impact or enhance the driving performance.

3.4 DEPENDENT VARIABLES

The following dependent variables were measured throughout the different music conditions and for all personality traits: the driving performance indicator for driving performance was the tracking deviation in metres, while the psychophysiological measures consisted of the heart rate frequency and heart rate variability, pupil diameter, eye speeds, fixation duration, blink frequency and blink duration (Acharya *et al*., 2006; Fairclough and Roberts, 2011). Subjective measures were also included as they are useful in the ability to assess factors that would not have been feasible to address solely by objective methods. These measures included the participants' perception, as well as environmental factors and motivational states that may otherwise impact the overall findings (Nilsson *et al*., 1997).

3.5 PSYCHOPHYSIOLOGICAL INDICATORS

3.5.1 Heart rate frequency and heart rate variability

Heart rate frequency and heart rate variability measures are considered the most popular technique in demonstrating a systematic and reliable relationship between the task demands or stimuli and how the heart functions or responds to those specific stimuli (Brodsky, 2001; Galy *et al*., 2012; Lin *et al*., 2008). A faster heart rate frequency is ostensibly linked to feelings of fear, arousal, anxiety and many more (Fairclough and Roberts, 2011; Galy *et al*., 2012). The heart rate frequency of an individual is also said to increase with increase in cognitively demanding tasks or sustained attention, but will be reduced for the heat rate variability (Galy *et al*. 2012). Therefore, during reduced cognitively demanding tasks, the heart rate frequency is reduced, and heart rate variability is increased (Acharya *et al*., 2006; Galy *et al*., 2012). Fairclough and Roberts (2011) and Galy *et al*. (2012) state that music imposes on the mental load, arousal, emotional and motivational states of the individual, implying that heart rate frequency and heart rate variability may be affected. Observing differences in heart rate frequency and heart rate variability may establish the extent to which different personality traits cope with the different music conditions while driving and the effect on the driving performance (Fairclough and Roberts, 2011; Galy *et al*., 2012). Cardiovascular parameters such as the heart rate frequency and heart rate variability are useful in indicating the attention aspects, arousal, an individual's mental load or efforts and overall state of being (Fairclough and Roberts, 2011; Ünal *et al*., 2013).

3.5.2 Pupil diameter

The eye tracker has the ability to identify the diameter of the pupil as it changes between tasks and tasks demand (Goble, 2012) with the pupil vaso-dilating and vaso-constricting when the individual is experiencing various mental workloads and other peripheral issues that may be triggered by a state of arousal or sensation seeking. Lin *et al*. (2008) agree and say that pupil size is correlated to increased mental workload. The evidence and data from pupillary response is a reliable indicator of mental load (Lin *et al*., 2008). Therefore, the dynamic pupil filter with a minimum pupil size (area) of 2 mm and pupil size greater than 20% per 100 ms period was employed to exclude any change in the pupil size during testing (De Gray Birch, 2012).

3.5.3 Eye speeds

The saccadic velocity represented as the speed with which the eye moves from one fixation to the next and the eye speeds in this study were measured at 5 to 30 °/s. Further, small saccades would be expected during the tracking task, as only the road had to be focused. De Gray Birch (2012) state that while saccades typically occur at a much greater speed, the lower threshold was considered more suitable due to the low pass filter function caused by the temporal resolution of the Dikablis system.

3.5.4 Fixation Duration

Fixation duration is defined as the time between the successive saccades (Schleicher *et al*., 2008; De Gray Birch, 2012). Fixation duration is also known as the static gaze and it generally lasts for 200-300 ms (Lin *et al*., 2008; De Gray Birch, 2012). Fixation duration is mostly used as the variable to determine the workload and fatigue. According to Schleicher *et al*. (2008) the variable fixation duration is closely related to the cognitive processing in attentive participants, but the relationship between fixation duration and fatigue has not necessarily been explicitly proved and documented. This is because fixation duration is said to have different length durations and these may propose different neuronal processes (Schleicher *et al.,* 2008; De Gray Birch, 2012). Very short fixation duration lengths (<150 ms) may be considered as a distinct category caused by low-level visuomotor behaviour, possibly reflecting automatic unconscious or non-cognitive aspects of behavioural control (De Gray Birch, 2012). Schleicher *et al*. (2008) show in their study that the mean scores of fixation duration and fatigue displayed no correlations but when the values are divided into very short (<150 ms), medium (150-900 ms) and very long (>900 ms), fixations of medium length showed a definite decrease in duration while very short and very long fixations increased in duration with fatigue. The eye motion analysis for fixation duration was analysed with eye movements that were less than 5°/s slope and greater than 100 and less than 1000 ms duration.

3.5.5 Blink frequency and blink duration

The blink frequency and blink duration are the number of times the eyelids close in one minute, the number of blinks that occur in that time is called the blink duration (Roche and King, 2010). Blink frequency and blink duration often also indicate alertness and fatigue/tiredness of the participants (Schleicher *et al*., 2008). The slower the blink frequency per minute the greater the signs of tiredness and fatigue (Schleicher *et al*., 2008). The blink frequency and blink duration may give an account as to the alertness of the participants during the three conditions. This study proposed to analyse blink frequency and blink duration taking into consideration the short and long blinks of participants during testing. The study therefore, measured the blink frequency and blink duration and divided the shorter blinks and longer blinks as it was predicted that the time on task effect would affect the overall blink frequency and blink duration readings as a result of fatigue effects (De Gray Birch, 2012). When considering the threshold for defining short and long blinks, the 90th percentile of blink duration was examined for all participants. The eye motion analysis and the minimum blink frequency was between three minutes and 30 minutes, implying the shortest and longest blink frequency. The blink duration ranged between 70 and 300 ms depicting shortest and longest duration respectively. Due to the low number of long blinks in the data because of the time frame of the study, a measure of total blink frequency and blink duration encompassing all extremely long blinks was annulled by considering the "short" blinks only. Blink frequency was calculated as the number of blinks per five minute interval (bl/min^{-1}), and blink duration was calculated as the average duration per five minute interval (ms).

3.6 SUBJECTIVE INDICATORS

The participants were asked to complete the Multidimensional Driving Style Inventory scale, once-off prior to the actual testing during the screening, habituation and introduction session (Appendix C3). The Multidimensional Driving Style Inventory scale assesses the participant's subjective driving styles under several driving circumstances. The Multidimensional Driving Style Inventory scale invented by Taubman-Ben-Ari *et al*. (2004) examines eight broad driving styles, namely the (Factor 1) dissociative driving, the anxious style (Factor 2), risky driving style (Factor 3), the angry driving style (Factor 4), high-velocity driving (Factor 5), distress-reduction driving style (Factor 6), patient (Factor 7) and careful style (Factor 8) (Taubman-Ben-Ari *et al*., 2012). For purposes of the study, the driving style refers to the way in which the motorists choose to drive, with autonomy of changing speeds, habitual levels of attentiveness, and assertiveness (Taubman-Ben-Ari *et al*., 2012). Taubman-Ben-Ari *et al*. (2012, p. 416) state the choice in driving styles is further "influenced by attitudes, beliefs regarding driving, needs and values and in addition the influence of different music intensities". Sensation-seeking individuals are those who are willing to take risks "for the sake of arousal and stimulation" (Zuckerman *et al*., 1990, p. 209) and angrier drivers are prone to risky behaviour and have a higher percentage at being involved in an accident than less agitated drivers. The Multidimensional Driving Style Inventory scale is made up of 44 questions that examined the eight broad driving styles and how each participant rated the extent each statement describes the participant's driving style. The participants rated the questions according to a six-point scale with the numerical value one denoting "not at all" and six "very much".

The NASA-TLX scale (Appendix C2) looks at the extent of the participant's mental load during imposed music intensities of the different conditions as the increase of mental load may affect the functional state of the participants which may influence the driving outcome (Galy *et al*., 2012). NASA-TLX scale is a multidimensional subjective workload index that uses six dimensions to assess mental workload, namely mental demand, physical demand, temporal demand, performance, performance, effort and frustration (Brookings *et al*., 1996, Galy *et al*., 2013; Ikuma *et al*., 2014). The scale is necessary to use as it has been found that the type of music played may impose on the mental workload of the participants and therefore their performance, effort and frustration and other dimensions (Galy *et al*., 2012).

The Perceived Control Scale (Appendix C1) which assesses the perception of participants driving ability and vehicular control was administered after conditions. A five point Likert scale was used with scores ranging from poor to excellent. The scale was assigned numbers from one to five in order to quantify the perceived control of the participants. The numerical value one indicates the worst driving ability and vehicular control and five denotes the best driving ability and vehicle control.

The subjective measures may indicate the underlying factors experienced by participants who may not otherwise be observed objectively and may enhance the quantitative data either indicating whether the participant's perceptions corroborates with that of the objective findings (De Gray Birch, 2012).

3.7 EQUIPMENT SETUP

3.7.1 Physical Driving Simulator Set-up

The hardware of the low fidelity driving simulator consists of custom built chassis seat, with a non-force feedback steering wheel (Louw, 2013). The Liesegang data projector, was placed approximately 2.14 m from the 2978 mm x 1700 mm white screen; and it had a luminance of 5.6 cd/m^2 (Louw, 2013). Luminance was measured using the Mavo-Spot 2 Digital Luminance meter. Luminance refers to the quantity of light travelling in a given direction that is emitted through a particular area (Bridger, 2008). The Liesegang projector was connected to a central laptop installed with the Human Kinetics and Ergonomics driving simulator software DrivSim v7-5-19, which shows the projection of the road (Göbel *et al*., 2008). Participants sit behind the wheel and are at a distance of approximately 1.55 m from the driver's eye point. The lighting in the laboratory room remained constant throughout testing and was measured at 557 lux. The laptop on the left played the music that participants listened to during the music conditions and the laptop on the right stored all the participants' eye measures (Figure 9 and 10).

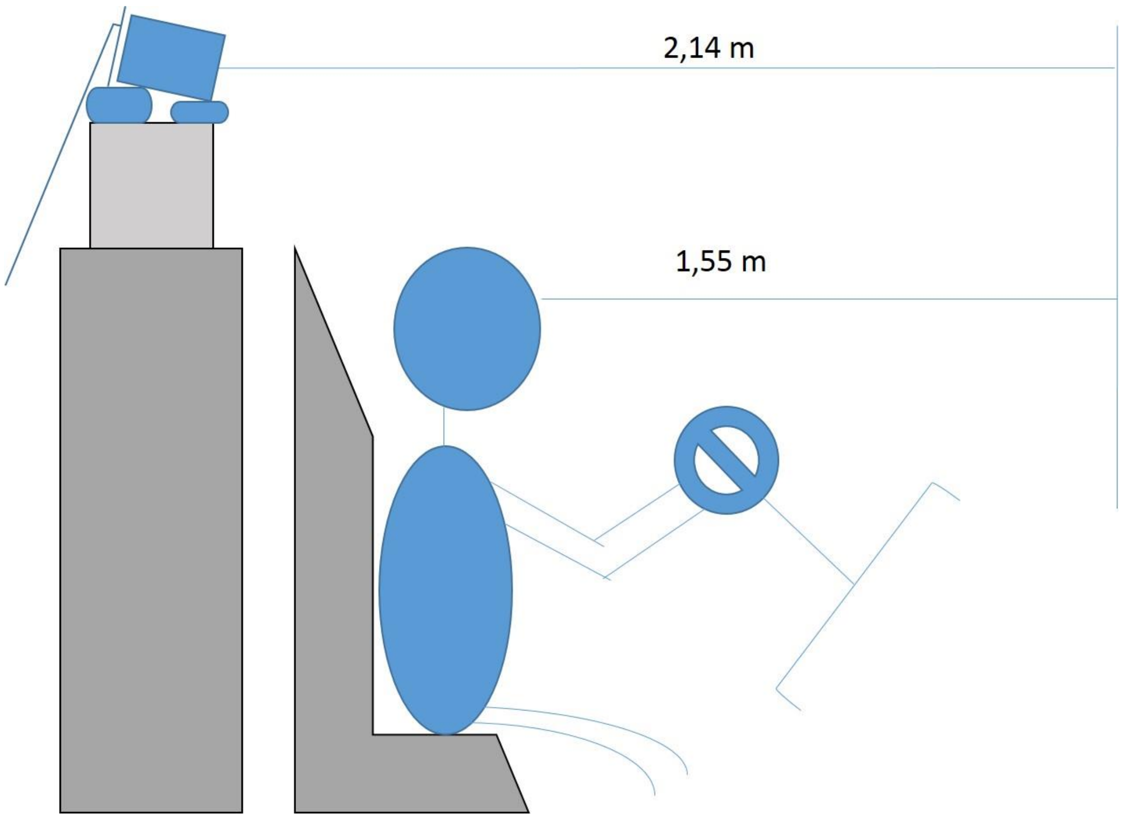

Figure 8: Schematic drawing of the physical driving simulator set-up.

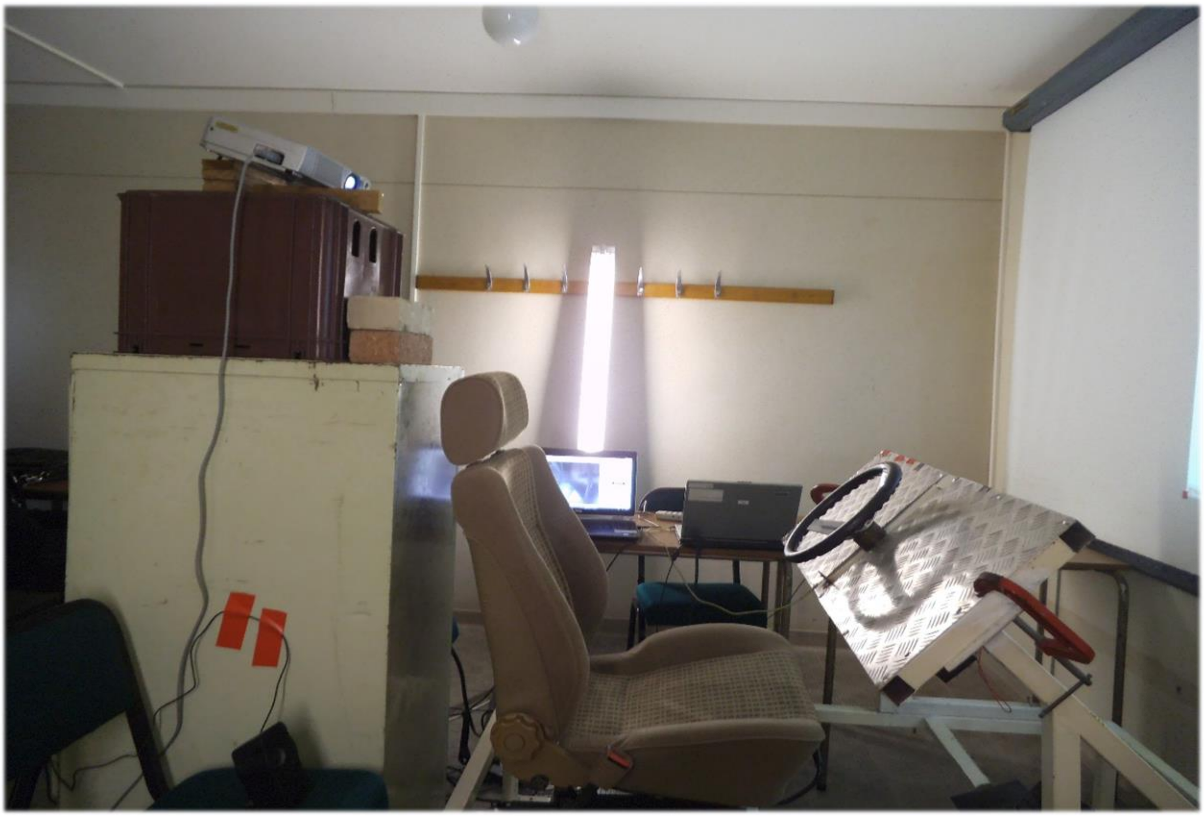

Figure 9 & 10: Side views of the full equipment set up.

Simulator Software

The simulator software was developed by Göbel *et al*. (1998). The simulated driving conditions replicate natural weather conditions and it includes: daytime hours, bright sunshine weather conditions; it had no pedestrian activity, no additional traffic, and it does not provide engine noise, tyre screeches, environmental noise and collision sounds (Brodsky, 2001; Hatfield and Chamberlain, 2008). Each area or part of the simulator scene was measured using the luminance meter and the yellow area which represents the bonnet of the vehicle was measured at 90 cd/m^2, the sky or blue area was measured at 57cd/m^2. The road (black area) was measured at 44 cd/m^2 and the grass (green area) was 92 cd/m^2. The simulator software allows for the change in route and perspective parameters, however to ensure consistency and reliability of the results regarding the objective variables, the parameters were kept constant (Appendix C5).

The driving simulator was chosen due to its limited demand on higher cognitive process, completely isolating the participants to the stimuli administered during the test. The simulator was also chosen in order to establish readings of the mean tracking deviation (Ünal *et al*., 2012). The simulator's software programme requires participants to complete a continuous tracking task where they follow a white line with the changing curvatures as precisely as possible. The yellow arrow represents the bonnet of the vehicle and the participants were encouraged to correctly steer and trace the white line (which separates the two lanes) with the changing curvatures as precisely as possible, which separates the two lanes (Figure 7). Furthermore the driving simulator was utilised in order to emulate a straight road monotonous long drive, as drivers are likely to listen to music to counteract the low arousal levels (Brodsky, 2012). In agreement with Reimer *et al*. (2009, p842) it must considered however that one of the challenges associated to simulation is the "development of scenarios that may encourage realistic driving behaviour patterns that are likely to provide insight into the behaviour relevant to real world driving."

Sound level analysis

The Logitech creative brand speakers were used to play music at the appropriate sound level for each condition. Prior to each of the music condition the sound level meter was used to ascertain the sound level per condition (moderate music at 50-65 dBA and loud music at 75-85 dBA) (Figure 10). The sound level meter was used to control the sound level per experimental condition measured in decibels (dBA) (Figure 10). A laptop was used to store each of the participants' music playlist. The playlist was encoded according to the participants' code number which was given during the habituation session. Each participant created his/her own play list from his/her own music collections and it consisted of 15 songs or more that would last throughout the 45 minute drive (Reimer *et al*., 2010). Ünal *et al.* (2013) and Brodsky and Slor (2013) claim that such a strategy increases *ecological validity* because the selected music by participants would be familiar to the participants as usually heard when driving or other different circumstances, increasing the true responses of the participants. A list of the songs for each of the participants was documented (Appendix C4).

Heart rate frequency and heart rate variability analysis

A Suunto T6 memory belt was used during all the conditions to record the participant's cardiac responses. A conductive gel was applied to the sensors of the Suunto belt and placed around .the mid-chest inferior to the pectoralis major muscle, in line with the apex of heart muscle (De Gray Birch, 2012; Ndaki, 2012). The conductive gel was used so to enhance the heart rate signals. Without the conductive gel there is a chance that the signals may be lost due to the lack of moisture and/or friction between the electrodes and the skin. The data was downloaded via a docking station onto a laptop with the Suunto Training manager 2.2.0.8 software. The Suunto heart rate monitor measures R-R intervals (which is the same as inter-beat intervals). These are used to calculate heart rate frequency and heart rate variability parameters.

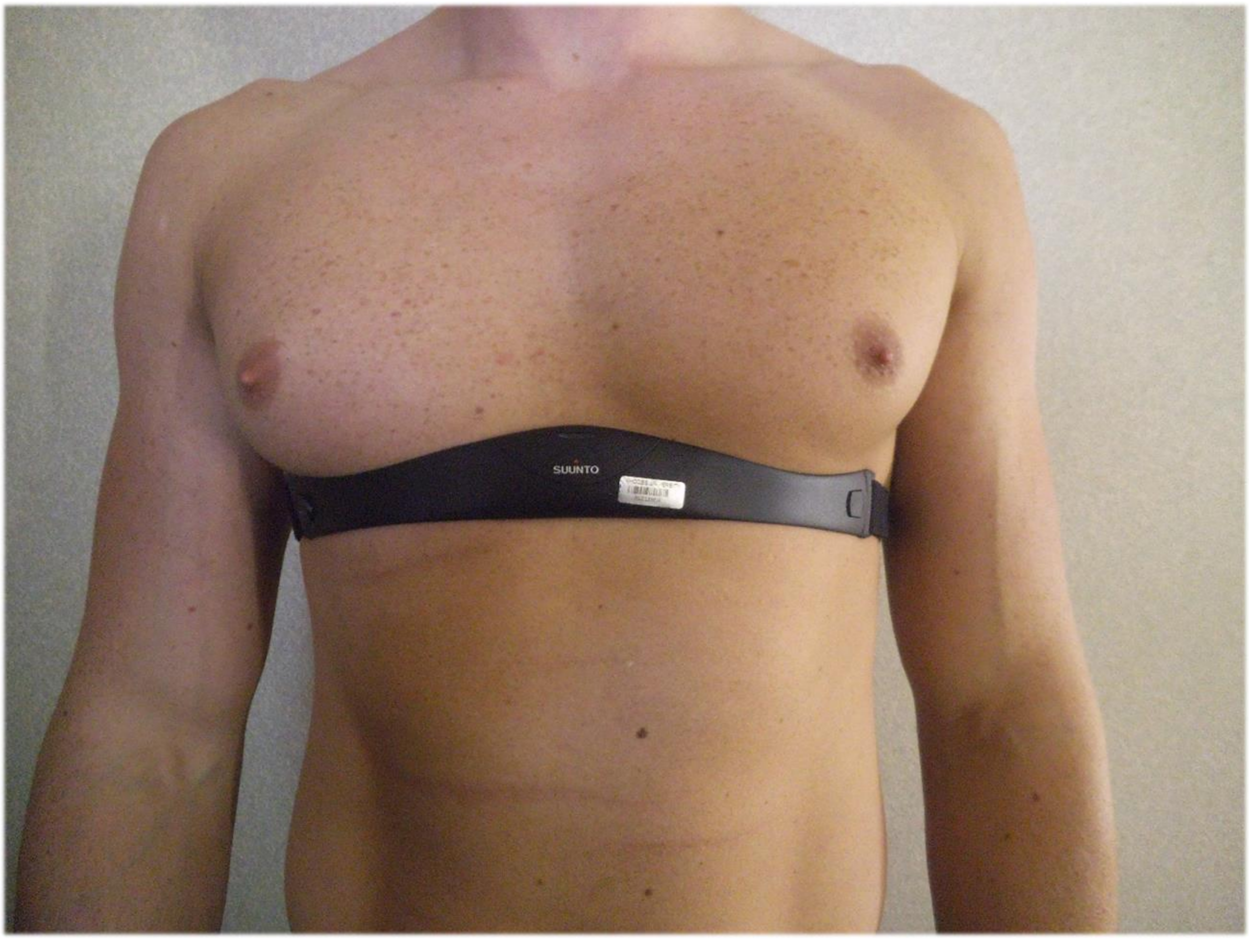

Figure 11: Participant fitted with the Suunto T6 memory belt.

Oculomotor measures analysis

The eye tracker was utilised to measure the various oculomotor responses throughout the testing sessions. The Dikablis head-mounted video-based eye tracker model is made up of three subunits: the head unit, the receiver unit with a power supply for the head unit of 230V, and the recording unit (recording laptop). The head unit was placed on the participant's head and was secured by the elastic band around the head. Comfort for the participant was provided by the spongy foam piece that sits on the fore-head, and nose pieces which are situated on the bridge of the participant's nose (Figure 12).

The head unit is made up of the field camera and the eye camera. The field camera records the field view of the participants whilst the eye camera, which is located above the left cheek records the cornea reflex and the pupillary movements. The cables of the field camera and eye camera run parallel to each other and behind the participant's head, which then the head unit sends information to the receiver unit. The information sent to the receiver unit is stored as both video and numerical coordinates of the pupil, which can be used to calculate all other eye movements such as the pupil diameter, fixations, saccades, and blink frequency and duration.

Figure 12: Doll fitted with the head unit of the Dikablis eye tracker (Louw, 2013, p. 55).

Subjective measure analysis

The subjective measures were used to correlate and substantiate the psychophysiological responses as well as the driving performance parameters obtained from the participants during the testing protocol as well as to determine the participants' responses of how they felt prior to the condition and during the condition. All subjective rating scales were pen to paper based scales. The initial scale administered was the NASA-TLX scale (Hart and Staveland, 1988; Andrews and Westerman, 2012). Then the perceived control scale, which was designed to measure the driver's subjective estimation of control and driving skills and the extent to which participants are aware of driving performance. This scale took the form of a 5-point Likert scale (1=poor to 5=excellent) (Appendix C1). These two scales were administered after each condition.

3.8 PARTICIPANT CHARACTERISTICS

A total of 25 non-professional, male and female drivers participated in this study. The participants formed a convenient sample from the Rhodes University student body and ages ranged between 19-35 years of age (Arnett, 1994; Rogé *et al*., 2004; Reimer *et al*., 2010; Constantinou *et al*., 2011 Park *et al*., 2013). Each personality trait category i.e. extraversion, agreeableness, conscientiousness, neuroticism and openness was used for assessing the twenty-five participants (Dahlen and White, 2006; Baker and Bichsel, 2006; Besharat *et al*., 2011; Dahlen *et al*., 2012; Park *et al*., 2013). The Rhodes University students were chosen because the groups were readily available for testing. Participants were seen suitable to participate in the study provided that they met the following requirements:

- That they were within the age range as proposed
- All ethnicities were included
- Participants had to have 1-5 years of driving experience
- Healthy participants as documented in the Review of Literature under (section 2.11).
- Those with normal and corrected to normal vision (contact lenses) were allowed to participate in the study. However, participants who wore spectacles were excluded from the study as the lens of the spectacles interferes with the accuracy of the eye tracking equipment to detect eye movement.
- Female participants were required not to wear face-make-up, eyeliner, mascara, and eye-shadow at least 48 hours prior to testing. Firstly the face make-up poses a hygiene issue for participants who are to take part in the study as the make-up may tinge the sponge of the eye tracker's head unit. Secondly the eyeliner, mascara, and eye-shadow directly interfere with the calibration of the eye tracker, this inevitably means that the pupil and therefore eye movements of the participant would not be detected, thus it would compromise overall results of the study.

The ages were chosen as a result of the South African driving laws that stipulate that individuals may obtain their driver's licence at the age of 18 years. In addition the ages were chosen as this is the young-adult category that makes most of the Rhodes University study body. Moreover this category of individuals is likely to listen to varying music intensities as compared to adults, and older citizens when driving, highlighting the possible responses of young-adult individuals and the responses thereof per different personality traits (Day *et al*., 2009). It should be noted that the main aim of the study does not look to compare different age groups, ethnicities or geographical locations in South Africa but it may however analyse data pertaining to these factors. This may be as considered for future studies surrounding this field of interest or research scope.

Table IV: Summary of the participants' characteristics.

Sex	No. of participants	Age (years)	Race
Female	16	20.7 (±1.2)	(1 Black) (2 coloured) (13 White)
Male	9	23 (±1.825742)	(4 black) (5 white)

3.9 ETHICAL CONSIDERATIONS

Ethical clearance was obtained from the Human Kinetics and Ergonomics Ethics Standard Committee prior to participant recruitment and execution of the study. The ethical application includes a detail description of the experimental protocol and procedure, as well as methodological considerations. The risks and benefits of the study were also highlighted in the application including participant requirements, which were expressed in the letter of information. It is highly unlikely that participants would experience life threatening risks; participants may experience minor discomfort from the heart rate monitor that is worn throughout the 45 minute drive as well as from the nose piece of the eye tracker. The ethics application also included privacy and anonymity considerations. All participants were tested individually; moreover the participants were given code names and all pictures taken for the study ensured that the identity of the participant is hidden, by blurring out the participant’s facial features. The consent form was given to the participant once all the information was provided and if participants were still willing to participate in the study of which the consent form was then signed by the participants, researcher and witnesses.

3.10 EXPERIMENTAL PROCEDURE

The experimental procedure was conducted in three different phases: the participant recruitment strategy, Screening, Habituation and Introduction, and Experimentation. Therefore, the participants came to the department several times to complete the study’s procedure.

3.10.1 Participant recruitment strategy

Several media were used to recruit the participants, but only occurred after ethical clearance was granted by the Human Kinetics and Ergonomics Ethics Standard Committee. A participant recruitment advert poster (Appendix A1) was distributed through electronic mail broadcasts which were distributed throughout the university’s Departmental and residential mailing lists. The poster was further distributed all over campus in the Human Kinetics and Ergonomics Departments, some of the University’s dining halls, the library and computer lab. Social media such as Twitter and Facebook were also utilised and lastly participants were recruited by word of mouth. During the recruitment process, potential participants were briefly notified of the study’s aim, the inclusion and exclusion criteria were highlighted. Those interested to participate in the study contacted the researcher via electronic mail and/or through mobile communication. Thereafter the potential participants were sent the consent form (Appendix B2), and Letter of Information (Appendix B1) which contained the details of the study and what was required of the, such as the procedure of the study and the risks and benefits. Thereafter, once the participants had read the Letter of Information and were still willing to continue with the study; a meeting was scheduled for the participants to attend the screening, habituation and introduction session at the Human Kinetics and Ergonomics Department.

3.10.2 Screening, Habituation and Introduction

Interested participants reported to the Human Kinetics and Ergonomics Department, on a day suitable to them. Participants attended in individual sessions**.** One of the requirements stipulated in the Letter of Information was for participants to bring the playlist of songs of their choice on a USB stick that would last 45 minutes or longer for the study's music conditions. The participants were introduced to the researcher and the following took place: the screening, habituation session as well as the introduction to the equipment- a session which ran for approximately 125 minutes and it included:

a) Participants attending an oral briefing of the study's aims, procedure and requirements at the Human Kinetics and Ergonomics Department
b) Participants would have with them the play list of songs on a USB stick. This music was then transferred to the laptop used in the study. Participants would then complete the screening questionnaire (Appendix A2), complete the once off Multidimensional Driving Style Inventory (Appendix C3) and complete the online Big-Five Inventory scale
c) if participants were still willing to participate, they would then sign the consent form (Appendix B2)
d) Familiarisation to the questionnaires (NASA-TLX and the Perceived Control Scale) and introduction to the equipment
e) Fitting of the heart rate monitor and eye tracker
f) Training period on the driving simulator that lasted 3 minutes
g) Debriefing.

A short debrief session took place highlighting the aims and procedure and experimental protocol of the study and what is required of the participants to complete and take part in the study (Appendix B1), after which the screening questionnaire was administered and looked towards verifying the eligibility of the participants that may take part in the study (Appendix A2). Participants were then given a code number so that the results would be tracked accordingly. The screening questionnaire included the following categories the inclusion and exclusion criteria, personal and demographic information in order to contact the participants for purposes of obtaining feedback once the study was complete as well as to keep track of the information gathered during the testing. Furthermore the screening questionnaire included questions related to driving experience, simulator experience, listening to music while driving experience and consequences of listening to music while driving, the intensity at which it's listened to and any accidents related to being distracted by listening to music while driving. Following this the participant's completed the Multidimensional Driving Style Inventory scale, which gives account of the participants' driving style (see Appendix C3). Lastly the participant completed the online Big-Five Inventory personality self-report scale; this established the dominant personality trait of the individuals see http://personality-testinö.info/tests/BIG5.php (Dahlen and White, 2006; Baker and Bichsel, 2006; Besharat *et al*., 2011; Dahlen *et al*., 2012; Park *et al*., 2013). Willing participants then signed the consent form.

The habituation session, took place immediately after the screening session. The participant was introduced to the various equipment (heart rate monitor, Dikablis eye tracker, and the low fidelity driving simulator). The researcher showed the participant the conducive gel and explained its purpose regarding the heart rate monitor. The conducive gel would be applied to the heart rate monitor's belt. The researcher explained that the conducive gel would not cause bodily discomfort or skin reactions. Thereafter the researcher demonstrated to the participant how the heart rate monitor ought to be worn. It was explained to the participant that the heart rate monitor is used to collect data pertaining to heart beats and heart rate variability. The Dikablis eye tracker was also shown to the participant and it was also explained that the Dikablis eye tracker would collect data pertaining to the participant's eye movements and that these two pieces of equipment would be worn throughout the 45 minute testing sessions. The researcher then asked the participant to have a seat on the low fidelity driving simulator and the requirements of the driving task were highlighted. The participants were informed that the yellow triangle represented the bonnet of the vehicle and they ought to drive on the white line separating the two lanes as accurately as possible (Figure 7). The researcher emphasised that the simulator would be different from normal driving, but the participant must remain in the mind-set of a realistic driving situation. Therefore, applying their own steering or driving technique, and taking the study as seriously as possible were emphasised.

The participant thus received a practice run on the driving simulator for a period of three minutes (Louw, 2013). This practice run was an opportunity for the participants to familiarise themselves as well as to engage with the researcher if the simulator was not understood or well received. At this point the screening, habituation and introduction to the equipment session had come to an end. Appointments were then scheduled with the participants to complete the three conditions.

Figure 13: A participant completing the Big-Five Online questionnaire during the habituation process in the Department of Human Kinetics and Ergonomics.

3.10.3 Experimentation

The testing took place at the Human Kinetics and Ergonomics Department laboratory for all three conditions. This room was a light-controlled room and all participants participated in this room in order to ensure a controlled environment as well as to eliminate light changes over the testing period, as this may affect eye measures negatively (De Gray Birch, 2012, Louw, 2013). The participants were tested between 9:00-12:00 and 14:30-17:00 so as to control the extent of the biological circadian factors that may affect performance. These periods align with the natural circadian rhythm of an individual (Wijesuriya *et al*., 2007). Each participant was given the opportunity to choose an appropriate testing time, based on availability as well as when they would be most alert. Upon arrival the researcher enquired on whether the requirements were upheld by the participant. If any of the requirements were not met, the researcher respectfully requested rescheduling of the testing session to a later date. The researcher again reminded the participant of the study and what was required. Participants were then fitted with the heart rate monitor, and as soon as it was worn the heart rate monitor would beep. The beep signalled that the researcher should record the chronological time at the start and end times, this was done so that the data would then be accurately processed in the appropriate time intervals. The participant was directed to take a seat on the low-fidelity simulator and for the participant adjusted the driving seat accordingly until he/she reached optimum comfort. Participants were reminded of the driving protocol and encouraged to drive as though in traffic applying vigilance and concentration. The participants were then fitted with the eye tracker and then the eye tracker was calibrated using markers on the projector screen, the participant's field view and according to the researcher's instructions. Recalibration of the eye tracker was done as necessary prior testing. Once the calibration was complete, the researcher asked that the participants inform the researcher if they experienced critical discomfort, nausea, simulator sickness and could no longer continue with the study once it occurred (Roenker *et al*., 2003; Reimer *et al*., 2010; Choi *et al*., 2013; Casutt *et al*., 2014) and most importantly the participants were reminded not to converse with the researcher during the testing. This is due to the reason that talking during the experiment would produce stochastic error, further influencing objective and subjective findings obtained. Participants were given a three minute practice run to remind them of how to complete the driving task each time for the three conditions (Reimer *et al*., 2010). When the participant was satisfied with the extent of the practice the study continued. The chronologic time of this transition period was also noted at the end.

The researcher then asked the participant to remain seated and calm for a period of 5 minutes in order to establish the baseline heart rate measurements after the transition period (Reimer *et al*., 2010). The chronological time was noted from the end of the transition phase and the end of the baseline heart rate.

The participant was then counted down in order to commence the first condition according to the permutation randomisation order table (Appendix D2). The chronological time at the start and the end of the condition or testing phase was also recorded. This helps with setting the necessary intervals of the heart rate frequency and heart rate variability measure for the data analysis. Thereafter, the participant completed the 45 minute drive. Following this, they completed the two subjective measures for post readings (Appendix C1-C2). At this point the testing session for this condition had come to an end and the participant was debriefed and notified of the next appointment to complete either of the remaining conditions. The conditions were tested on different days due to their availability, as well as to allow the participant rest and avoid a learning effect. Also, to avoid the potential of simulator sickness that is likely to occur from prolonged simulator driving, participants were not testing all in the same day (Brooks *et al*., 2010). Either the without music condition, moderate music condition at 55-65 dBA or the loud music condition at 75-85 dBA, had to be completed depending on the randomisation of the conditions of which the experimental protocol followed the same procedure (Brodsky and Kizner, 2012).

3.11 REDUCTION OF DATA & STATISTICAL ANALYSIS

3.11.1 Driving Performance

Considering the sensitivity of the steering wheel of the simulator as compared to the real life steering wheel, the initial 10 seconds of the deviation data was not considered in the data analysis. This is to allow for the drivers a chance to stabilise their driving performance at the start of the test (Göbel et al., 2008; Louw, 2013). In addition the initial output sample intervals was set at 5 seconds to produce due to the changes on street curvature and avoiding the strong variations from street curvatures (Göbel *et al*., 2008).

The driving data tracking deviation (m) and reaction time (s) were exported from the DriveSim v_7.5.19. Then it was transformed into the evaluate protocols, and was processed and expressed into Microsoft excel spread sheet, providing information on the tracking deviation (m), reaction time (s), info capacity (bit/s), and alteration frequency (1/s). However, relevant for this study only the tracking deviation and reaction time were further analysed. The data was analysed in one minute intervals. Thereafter further descriptive analysis (mean and standard deviation) was conducted on the existing data. Further inferential statistics were performed using Statistica software program version 12. Repeated measures analyses of variances (ANOVAs) were conducted to observe effect of condition differences, effect of personality differences, interactional effects, as well as co-variates in this instance (age and sex) were analysed.

3.11.2 Psychophysiological measures

3.11.2.1 Heart rate frequency and heart rate variability

Heart rate frequency and heart rate variability data collected from the Suunto heart monitor was downloaded and transferred via the Suunto Docking station and onto the laptop, and later converted into an sdf file. The heart rate frequency and heart rate variability were exported from the Training manager software Version 2.2.0. Using the Data Analysis Tool 3.4.12 developed by the Human Kinetics and Ergonomics Department. Exported data from the Training Manager is further processed heart rate frequency in (bpm),and the heart rate variability measures which included the following parameters: rMSSD (ms), SDNN (ms), PNN30 (%), PNN50 (%), High Frequency band (0.15-0.4 Hz), Low Frequency band (0.04-0.15 Hz) and Low Frequency and High Frequency ratio into excel spread sheet. The data was processed into 30 second and 5 minute intervals for both heart rate frequency and heart rate variability measures and only 15 minute intervals for heart rate variability measures of the 45 minute duration protocol across all the tests. The best of these intervals to assess and analyse the data was the 5 minute interval due to the model formulae Statistica 12 software uses. Descriptive data were conducted and documented and thereafter further inferences were conducted. The study observed differences in condition effects, personality traits, interactional effects, and co-variates (age and sex) were also analysed on heart rate frequency and heart rate variability for which the repeated measures analysis of variance (ANOVAs) was also conducted.

3.11.2.2 Oculomotor measures

Data collected on eye movements were saved as a journal-0000 txt file on the Dikablis eye tracker laptop. The files of the eye movements were extracted, processed and further reduced using the Human Kinetics and Ergonomics Data Analysis Tool 3.4.12. Thereafter the data was processed using the interval analysis process into 5 minute intervals and the data was processed and expressed on the Microsoft excel spreadsheet. The pupil diameter (mm), eye speeds (°/s), fixation duration (s), blink frequency (bl/min) and blink duration (ms) were further analysed using the Statistica 12 StatSoft software for inferential predications as a repeated measures analysis of variance (ANOVAs). Post hoc analyses were conducted on significant effects of pupil diameter.

3.11.3 Subjective Measures

The subjective measures data that of the perceived control and NASA-TLX were transposed onto Microsoft excel sheet and further processed and analysed using the Statistica 12 StatSoft software. Descriptive data (mean and standard deviation), inferential statistics was conducted (ANOVA’s, Post Hoc and Spearman Rank Order Correlations).

CHAPTER IV

4. RESULTS

INTRODUCTION

OVERVIEW

The following chapter gives an overview and an account of the results obtained during the experimental procedure. The study observes the findings associated with the performance, physiological parameters, oculomotor parameters and subjective parameters. The dependent variables were assessed to determine condition, personality traits and co-variates and interactional effects and whether these differed statistically. To reiterate the present study evaluated the effect different music intensities would have on different classifications on personality traits and the impact this would impose on driving performance over time. Participants were required to complete three conditions, one without music, one with moderate music, and loud music[1] over a 45 minute driving period uninterrupted. According to Louw (2012) the nature of this particular driving task is considered a submaximal drive, due to the fact that participant was required to steer on the white line, which would not necessarily require maximal attention to perform the task (Figure 7). Participants performed all of the conditions consequently taking on the repeated measures design.

All participants that volunteered in the study and were exposed to a screening, habituation and introduction session prior to answering participation questionnaires. Driving performance was measured continuously. Concerning the psychophysiological perspective the following variables were measured and analysed: heart rate frequency, heart rate variability, and oculomotor measures (pupil diameter, fixation duration, eye speeds, blink frequency and blink duration). Subjective measures were also analysed including the Multidimensional Driving Style Inventory, NASA-Task Load Index and perceived control.

[1] Without music=no music played during this condition, moderate music=50-65 decibels of music played at that intensity, loud music=75-85 decibels of music played at that intensity.

4.1 KEY CONSIDERATIONS FOR STATISTICAL INTERPRETATIONS

The data in each category was analysed using descriptive statistics and then inferential statistics. The descriptive statistics refers to the:

- Mean
- Standard deviation (error bars)

The mean and standard deviations were calculated using the Microsoft Excel Software Programme. Inferential statistics were considered in order to draw statistical significance for the parameters. The inferential statistics for each category looked at:

- Repeated analysis of variance for all variables
- Post Hoc analyses were calculated for oculomotor parameters (pupil diameter)
- Spearman Rank order correlations were performed for the subjective measures (Multidimensional Driving Style Inventory, NASA-Task Load Index and perceived control).

In each parameter the performance, physiology, oculomotor and subjective parameters looked at the effect of condition, the effect of personality traits and effect of co-variate age and sex. Throughout the results, discussion and conclusion chapters various statistical terms are used to describe the outcome of the findings. The time on task effect, which refers to the changes over the exposed time in the task, otherwise also stated as the change in dependent variables over the proposed time period (De Gray Birch, 2012; Louw, 2013). Interactional effect speaks to the relationship between all considered variables for example, the condition*time on task*personality trait.

In the statistical model age and sex were assessed as co-variates throughout all analyses. The age and sex when added to the statistical analysis tended to elicit effect on various variables particularly on time on task in some instances, conditions and traits in others; this however, may be due to the low participant sample. All the statistical analyses were performed with a confidence interval of 95% ($p<0.05$). The vertical bars or errors bars denoted a 95% confidence interval.

Due to the extent and complexity of the data, non-significant and significant results are discussed as it is believed that whilst some of the data does not reveal statistical significance it may illustrate the possible indirect findings that may be necessary to document as part of the study, giving a candid account and implications of the findings thereof, which may not necessarily be reflected in the direct findings.

Detailed tables summarising relevant statistical effects are included at the beginning of each section and the figures illustrate the pattern of change throughout the 45 minute driving task. Complete statistical tables that demonstrated no statistical significance are listed in Appendix E.

Table V: A summary table illustrating the significant results of the *condition*, *time on task*, *personality traits*, *age and sex*. A shading in the box, demonstrates significance of the results. Please note the following letters and their meaning. P=parameters, V=variables (T.D=Tracking deviation, R.T=Reaction time), C=conditions, T=time on task, A=age, S=sex and the letters (E, A, C, N, O) stand for the personality traits. The asterisk between each variable denotes the interactional relationships. The different colours denote the significant effects within the different variables.

P	V	C	T	Personality					C*Trait					C*T	T*traits					C*T*Traits					A	C*A	T*A	C*T*A	C*S	T*S	C*T*S
				E	A	C	N	O	E	A	C	N	O		E	A	C	N	O	E	A	C	N	O							
Performance	T.D																														
	R.T																														
Physiology	HRF																														
	rMSSD																														
	SDNN																														
	PNN30																														
	PNN50																														
	HF power																														
	HF(cf)																														
	LF power																														
	LF(cf)																														
	LF+HF																														

Continuation Table V

Oculomotor	Pupil diameter																														
	Eye speeds																														
	Fixation duration																														
	Blink frequency																														
	Blink duration																														
Subjective	MDSI																														
	NASA-TLX																														
	Perceived control																														

4.2 DRIVING PERFORMANCE PARAMETERS

Tracking Deviation

Effect of Condition

The mean and standard deviation of the tracking deviation were calculated for the different conditions (without music, moderate music, loud music). The scores are tabulated as follows in (Table VI). As stated by (Louw, 2013) the tracking deviation unit measured in metres should be considered as an arbitrary unit as it only corresponds to the road geometry of the specific simulator used in the study. In addition the repeated measures analysis of variance on the effect condition tracking deviation (m) without any co-variates, were calculated and it yielded no significant results on tracking deviation (Appendix E).

Table VI: Mean and standard deviation (±) of the driving deviation for the different conditions (n=25).

Without music	Moderate music	Loud music
0.1294 (±1.997430)	0.0472 (± 0.33535)	0.0102 (± 0.00187)

Effect of Personality traits

Table VII: Repeated analysis of variance on the effect on tracking deviation (m) with the factors condition and all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Extraversion	5462	1, 18	5461.758	3.212	0.089938
Agreeableness	794	1, 18	794.334	0.467	0.503027562
Conscientiousness	97	1, 18	96.93	0.057	0.814000857
Neuroticism	6624	1, 18	6624.181	3.895	0.063974209
Openness	481	1, 18	481.02	0.283	0.601336354
Condition	2252	2, 36	1125.853	0.655	0.525395668
condition*extraversion	10576	2, 36	5288.105	3.078	0.058356868
condition*agreeableness	1678	2, 36	839.1901	0.488	0.617607922
condition*conscientiousness	249	2, 36	124.3742	0.072	0.930306788
condition*neuroticism	13029	2, 36	6514.564	3.791489	*0.032043574
condition*openness	779	2, 36	389.2659	0.226554	0.798404737
time on task	28752.03	45, 810	638.9339	0.763941	0.870399221
time on task*extraversion	114346.3	45, 810	2541.029	3.038179	*<0.01
time on task*agreeableness	18205.59	45, 810	404.5688	0.483722	0.998419912
time on task*conscientiousness	1974.795	45, 810	43.88434	0.05247	1
time on task*neuroticism	151863.4	45, 810	3374.741	4.035006	*<0.01
time on task*openness	10190.81	45, 810	226.4624	0.270769	0.999999649
condition*time on task	57603.38	90, 1620	640.0375	0.765402	0.948578219
condition*time on task*extraversion	228827.6	90, 1620	2542.529	3.040536	*<0.01
condition*time on task*agreeableness	36372.15	90, 1620	404.135	0.483293	0.999988218
condition*time on task*conscientiousness	3921.994	90, 1620	43.57771	0.052113	1.000000
condition*time on task*neuroticism	303857	90, 1620	3376.189	4.037486	*<0.01
condition*time on task*openness	20499.89	90, 1620	227.7766	0.272391	1.000000

Repeated measures analysis of variance for the tracking deviation with the factors condition and all personality traits revealed that none of the personality traits on their own yield a significant effect on the tracking deviation (m). However, the interaction between the factors condition and personality traits only generated a significant effect for that of neuroticism participants. That is neuroticism participants illustrated differences on tracking deviation (m) and the differences of the conditions (without music, moderate music, loud music). The time on task had no effect on the tracking deviation (m), however there's an interactional effect between the personality traits, particularly, extraverts and neuroticism and time on task. This implies that the change of performance over the duration of the task is affected by how strongly an individual rates on the extravert and neuroticism scales. There is an interaction effect between the condition, time on task and the traits extraversion and neuroticism on tracking deviation. That is the conditions might also affect the two personality traits.

Effect of co-variates age and sex

Table VIII: Repeated analysis of variance established on tracking deviation (m) with the factors conditions and covariate age during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Age	3109.409	1, 22	3109.409	1.730309	0.201916548
Conditions	5587.9527	2, 44	2793.976	1.554046	0.222770539
conditions*age	6431.0951	2, 44	3215.548	1.788529	0.17914806
time on task	60384	45, 990	1341.862	1.522175	*0.016056733
time on task*Age	69396	45, 990	1542.125	1.749347	*0.001909867
conditions*time on task	120654	90, 1980	1340.601	1.520713	*0.001444461
conditions* time on task*age	138680	90, 1980	1540.893	1.747915	*<0.01

Repeated measures analysis of variance for tracking deviation with the factors condition and covariate age showed no significant results. However, there is significant effect of the time on task on tracking deviation (m) as well as interactional effect of the time on task and *age* and interactional effect of condition, time on task and age. This implies that the variables interact together, one with the other yields significance (p<0.05, Table VIII).

Table IX: Repeated analysis of variance established on tracking deviation (m) with the factors conditions and covariate sex during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Sex	2514	1,22	2514.398	1.378454	0.252918
conditions *sex	5219	2,44	2609.291	1.429411	0.25031
time on task	59418	45,990	1320.399	1.473924	*0.024192
conditions*time on task	118916	90, 1980	1321.289	1.4749	*0.00296
conditions*time on task*sex	110389	90, 1980	1226.547	1.369144	*0.013601

The variable sex on its own displays no significant effect on the tracking deviation (m). The *condition* (without music, moderate music, loud music) and *sex* variables together yield no significance, however there is a significant effect on the time on task, and interactional effect between the condition and time on task as well as the condition, time on task and sex. This suggests that the longer the participants have to drive or the time spent on the task the more varied the tracking deviation (m) from the middle line of the simulator (Figure 7) which can be found in section 3.2.1.3. Condition and time on task interactional effect suggests that the conditions (without music, moderate music, and loud music) and the time spent on the task will affect the tracking deviation of participants. Therefore, the suggestion that music is effective in alleviating sleepy mode states or fatigue might not be efficient to use as a coping mechanism during long distance drives.

Reaction Time

Effect of Condition

The mean and standard deviations were calculated for the different conditions (without music, moderate music, loud music) for reaction time (s). Repeated measures analysis of variance for reaction time with the factors condition, without covariates displayed no significant results. Neither the conditions nor time on task and interactional effect between conditions*time on task has a significant effect on the reaction time (s) of the participants (see Appendix E).

Table X: Mean and standard deviation (±) of the driving deviation for the different conditions (n=25).

Without music	Moderate music	Loud music
0.396782 (± 93.01183)	0.303914 (± 1.320557)	0.078879 (± 0.059907)

Effect of Personality Traits

Table XI: Repeated analysis of variance established for reaction time (s) with the factors conditions and all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	69.929	1, 14	69.92935	1.940113	0.185381318
Agreeableness	4.408	1, 14	4.408171	0.1223	0.731758298
Conscientiousness	8.629	1, 14	8.629077	0.239404	0.63221356
Neuroticism	91.419	1, 14	91.41856	2.536307	0.133575303
Openness	0.001	1, 14	0.001182	3.28E-05	0.99551086
Conditions	500.348	2, 28	250.174	7.125015	*0.003152347
conditions*extraversion	44.74831	2, 28	22.37416	0.637221	0.536255218
conditions*agreeableness	3.554203	2, 28	1.777101	0.050612	0.950733957
conditions*conscientiousness	288.374	2, 28	144.187	4.10648	*0.027297068
conditions*neuroticism	383.5118	2, 28	191.7559	5.461254	*0.009940331
conditions*openness	252.8357	2, 28	126.4179	3.600411	*0.040595057
time on task	875.9624	45, 630	19.46583	6.194162	*<0.01
time on task*extraversion	134.3534	45, 630	2.985632	0.950049	0.567325
time on task*agreeableness	5.821686	45, 630	0.129371	0.041167	1.000000
time on task*conscientiousness	399.328	45, 630	8.87396	2.823756	*1.09E-08
time on task*neuroticism	755.596	45, 630	16.79102	5.343018	*<0.01
time on task*openness	304.639	45, 630	6.769762	2.154185	*3.25289E-05
conditions*time on task	1768.840	90, 1260	19.6538	6.207852	*<0.01
conditions*time on task*extraversion	256.4015	90, 1260	2.8489	0.899857	0.73511487
conditions*time on task*agreeableness	10.800	90, 1260	0.1200	0.037905	1.000000
conditions*time on task*conscientiousness	819.422	90, 1260	9.1047	2.875812	*4.44089E-16
condition*time on task*neuroticism	1521.352	90, 1260	16.9039	5.339277	*<0.01
condition*time on task*openness	624.397	90, 1260	6.9377	2.191360	*4.55193E-09

Neither of the personality traits (extraversion, agreeableness, conscientiousness, neuroticism, and openness) revealed significant results on the variable reaction time (s). In figure 14, the conditions show significant results on the reaction time (s), with the without music condition having a value of 0.396782 (s), and moderate music at 0.303914 (s) and lastly the loud music at 0.078879 (s). The least of these conditions to have an effect on the reaction time is the loud music, second to this is the moderate music and the greatest contributor to affect the reaction time (s) is the condition without music. This means that reaction time was worse during the without music condition and least for the loud music condition. There are differences in the variance for the different conditions. With the without music condition demonstrating the greatest variance, then followed by the moderate music condition and the least variance is the loud music amongst the participants. There is an interactional effect on the conditions and personality traits namely conscientiousness at (p=0.0273; Table XI), neuroticism (p=0.00994; Table XI), and openness (p=0.04059; Table XI). That is the personality traits conscientiousness, neuroticism, and openness are affected by differences in the conditions (without music, moderate music, loud music). The time on task also has an impact on the reaction time (s) at p value of <0.01. There is an interactional effect between the time on task and the personality traits conscientiousness (p<0.01; Table XI), neuroticism (p<0.01; Table XI), and openness (p=3.25E-05; Table XI). The duration of the driving task impacted these personality types named above and therefore affected the participant's reaction time ability (s). There is also significant effect between the condition and the time on task and an interactional effect of the condition time on task and traits (conscientiousness, neuroticism, and openness).

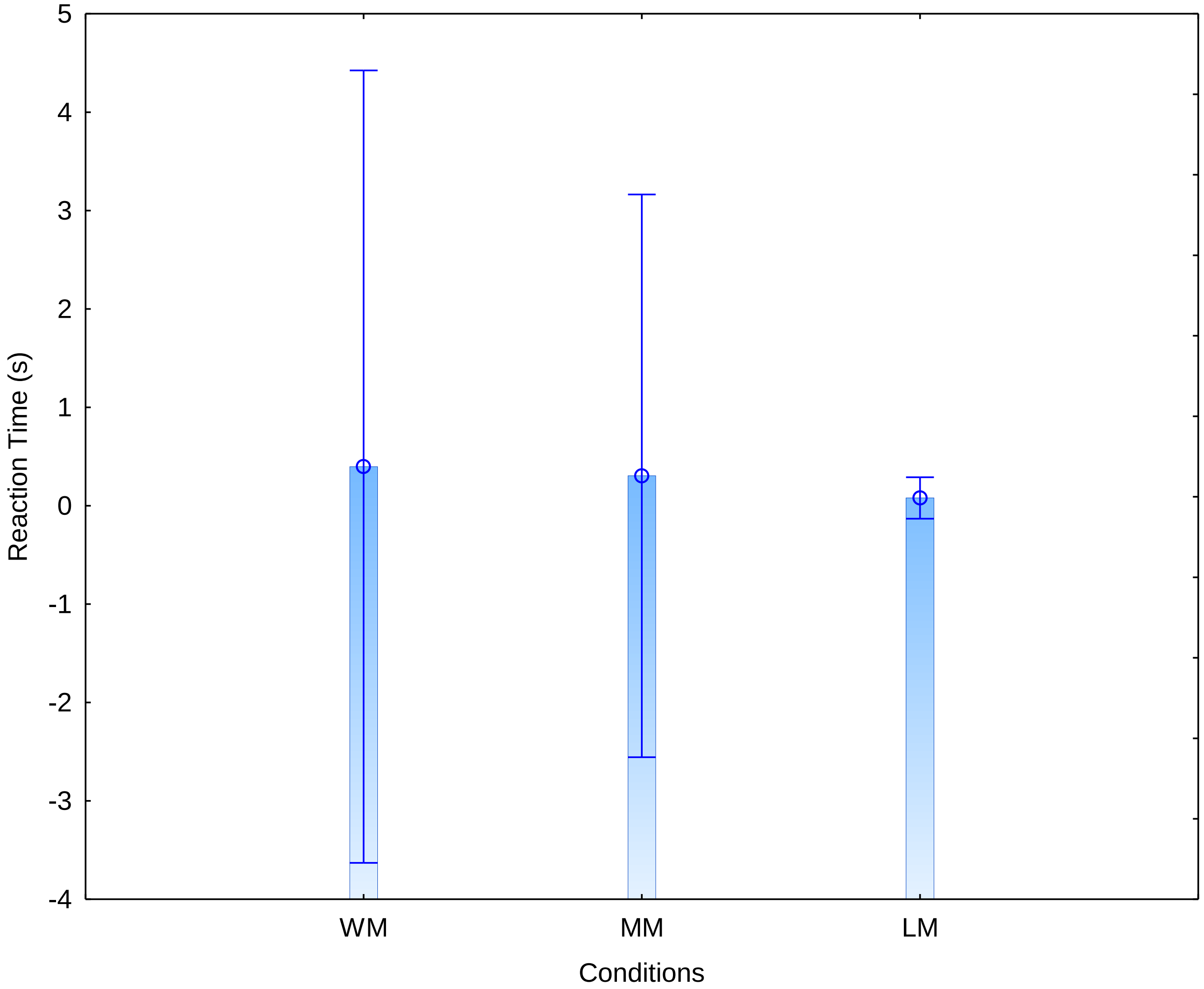

Figure 14: Differences in reaction time (s) for the different conditions. Without music, demonstrates the worst effect, second to this is moderate music, loud music showing little effect. Current effect is $F(2, 28) = 7.1250$, $p=0.0315$ (*= significant, $p<0.05$, Error bars denote the 95% confidence interval).

Effect of co-variates age and sex

Repeated analysis of variance conducted on the conditions with covariate age indicated non-significant results on reaction time (s) (see Appendix E).

Table XII: Repeated analysis of variance for reaction time (s) established with the factors conditions and covariate sex during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Sex	21.33972	1, 18	21.33972	0.504907	0.486457
Conditions	87.67349	2, 36	43.83675	0.99727	0.378847
conditions*sex	170.1089	2, 36	85.05444	1.934958	0.159158
time on task	297.1695	45, 810	6.603766	1.688429	*0.003685
time on task*sex	285.5035	45, 810	6.344523	1.622146	*0.006856
conditions*time on task	577.6357	90, 1620	6.418175	1.640194	*0.000211
conditions*time on task*sex	588.1517	90, 1620	6.535018	1.670054	*0.000124

Repeated analysis of variance for reaction time (s) with the factors conditions and covariate sex show that that there is an effect on time on task on reaction time (Figure 14). There is an effect of time on task and sex (p=0.003685; Table XII) show significant results on reaction time as well the conditions and time on task (p=0.000211; Table XII), and conditions, time on task and sex (p=0.000124; Table XII).

4.3 CARDIOVASCULAR PARAMETERS

Heart Rate Frequency

Effect of condition

The mean and standard deviation values of the heart rate frequency (bt.min^{-1}) can be found in Table XIII. The repeated measures analyses of variance on the effect the condition on heart rate frequency without any co-variates, were calculated and showed no statistical significance of the conditions on heart rate frequency. This indicates that the change in the conditions (without music, moderate music, loud music) has no effect on the changes in the heart rate frequency. However, there is statistical significance of the time on task on heart rate frequency. Heart rate frequency (bt.min^{-1}) illustrates significant decrease over time from 72 bt.min^{-1} to 70 bt.min^{-1} at the end of the driving task (Figure 15). The decrease in heart rate frequency is indicative of participants showing signs of a relaxed state or fatigue. There is no interactional effect between the conditions and the time on task on heart rate frequency.

Table XIII: Mean and standard deviation (±) of the heart rate frequency (bt.min^{-1}) for the different conditions (n=25).

Without music	Moderate music	Loud music
70.447 (±0.574443641)	72.012 (±0.671378765)	71.782 (±0.75650353)

Table XIV: Repeated analysis of variance on heart rate frequency (bt.min^{-1}) established with the factor condition without covariates during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Condition	321	2, 48	161	0.652	0.525703
time on task	144	8, 192	18	2.907	*0.004408
condition*time on task	59	16, 384	4	1.292	0.198704

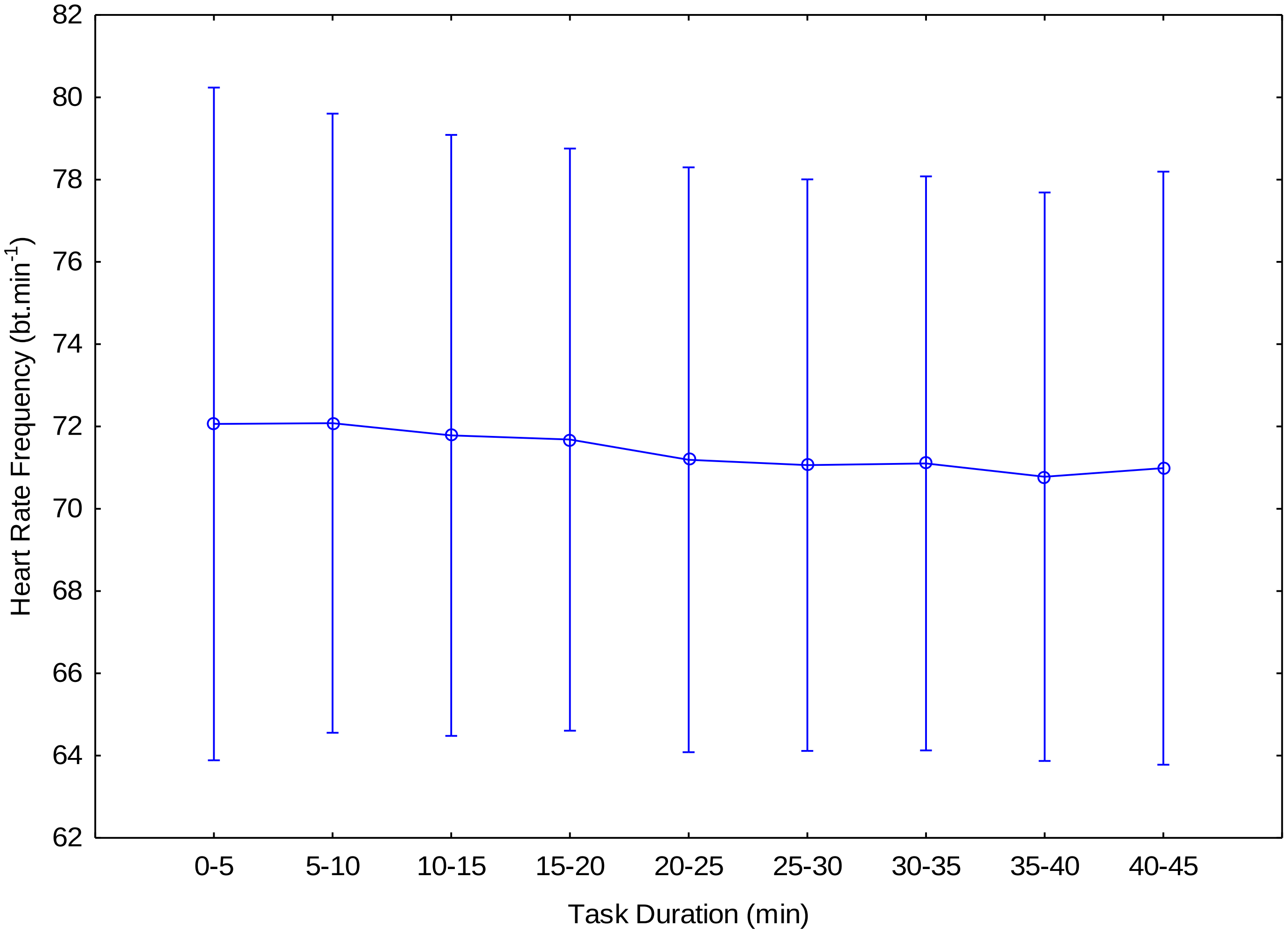

Figure 15: Heart rate frequency (bt.min^{-1}) significantly decreases over time, $p<0.05$; Error bars denote the 95% confidence interval. Current effect: $F (8, 192) =2.9068$, $p=0.004408$.

Effect of Personality Traits

Table XV: Repeated analysis of variance on heart rate frequency (bt.min^{-1}) established with the factors condition and all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Extraversion	10703.000	1, 19	10703	4.703527	*0.042999
Agreeableness	5544.47	1, 19	5544.47	2.436565	0.135037699
Conscientiousness	1715.57	1, 19	1715.57	0.753922	0.396072663
Neuroticism	2837.61	1,19	2837.61	1.247013	0.278047205
Openness	307.17	1, 19	307.17	0.134989	0.717375385
Conditions	29.93	2, 38	14.96291	0.055128	0.946439593
conditions*extraversion	398.55	2, 38	199.2773	0.734199	0.486572981
conditions*agreeableness	678.86	2, 38	339.4302	1.250565	0.29786035
conditions*conscientiousness	415.38	2, 38	207.6897	0.765192	0.472278891
conditions*neuroticism	190.31	2, 38	95.1549	0.35058	0.706533468
conditions*openness	235.65	2, 38	117.8238	0.434099	0.651020405
time on task	150.89	8 , 152	18.86079	4.125895	*0.000176177
time on task*extraversion	54.08	8, 152	6.759911	1.478765	0.169247322
time on task*agreeableness	28.06	8 , 152	3.50807	0.767408	0.631969543
time on task*Conscientiousness	49.27	8, 152	6.159084	1.347331	0.224365448
time on task*neuroticism	273.87	8, 152	34.23343	7.488739	*2.12948E-08
time on task*openness	22.39	8, 152	2.798615	0.612211	0.766640653
conditions*time on task	61.5518198	16, 304	3.846989	1.286907	0.203709914
conditions*time on task*extraversion	18.34698119	16, 304	1.146686	0.383593	0.985597639
conditions*time on task*agreeableness	38.80739806	16, 304	2.425462	0.811373	0.672558817
conditions*time on task*Conscientiousness	36.09881426	16, 304	2.256176	0.754743	0.736186288
conditions*time on task *neuroticism	44.61253762	16, 304	2.788284	0.932746	0.531850493
conditions*time on task*openness	38.73827956	16, 304	2.421142	0.809928	0.674216573

Extraversion on its own has a significant effect on the heart rate frequency (bt.min^{-1}) at (p=0.042999; Table XV). This suggests that the heart rate frequency of the personality trait-extraversion is likely to change throughout a driving task. The other personality traits show no changes or effect on the heart rate frequency. Time on task significantly produces changes in the heart rate frequency (bt.min^{-1}) at (p=0.000176177; Table XV). The longer the time spent on a given task, the more likely for the heart rate frequency will decrease over time. This decrease in heart rate frequency is an indication of the possible symptoms of sleepiness or fatigue (Acharya *et al*., 2006; ChuDuc *et al*., 2013). There is an interactional effect of the time on task and neuroticism personality trait on heart rate frequency at (p=2.1948E-08; Table XV). Neuroticism personality types are more affected by the time on the task. There is no significant effect on the interactional relationship between condition and the time on task and on the conditions the time on task and the personality traits.

Effect of co-variates age and sex

Repeated analysis of variance conducted on heart rate frequency (bt.min^{-1}) with factors condition and co-variate age, show that there was no statistical significance found for these variables (see Appendix E). The repeated analysis of variance statistics with the factors conditions and co-variate sex were calculated and sex differences on heart rate frequency yielded no statistical significance. However, there is a time on task effect on heart rate frequency (bt.min^{-1}) (Table XVI).

Table XVI: Repeated analysis of variance examining heart rate frequency (bt.min^{-1}) established with the factor conditions and co-variate sex during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Sex	2004	1, 23	2004.233	0.725299	0.403192
Condition	304	2, 46	151.9629	0.638803	0.532542
condition*Sex	891	2, 46	445.4246	1.872423	0.165281
time on task	174	8, 184	21.76093	3.541275	*0.000774
time on task*Sex	61	8, 184	7.674866	1.248973	0.273035
condition*time on task	50	16, 368	3.104495	1.101241	0.351769
condition*time on task*Sex	59	16, 368	3.703596	1.313756	0.185250

Heart Rate Variability: Time domain analyses

rMSSD

Effect of Condition

Descriptive statistics on the mean and standard deviation were calculated for the heart rate variability rMSSD (Table XVII). The repeated analysis of variance established on the heart rate variability rMSSD (ms) with the factor condition without co-variates during the driving condition (without music, moderate music and loud music) show no condition effects;, however, the time on task has a statistical significance on the heart rate variability rMSSD (ms). Conditions and the time on task together have no effect on the heart rate variability (Table XVIII). Figure 16, illustrates the changes of the heart rate variability for rMSSD. The increase in heart rate variability from 44.56 (ms) to 50.73 (ms) corresponds with the theory that pertains to heart rate variability, that an increase in heart rate variability affects the parasympathetic nervous system and therefore showing signs of fatigue and/or a sleepy state (Acharya *et al*., 2006; ChuDuc *et al*., 2013).

Table XVII: Mean and standard deviation (±) of the heart rate variability (rMSSD) (ms) for the different conditions (n=25).

Without music	Moderate music	Loud music
49.44058 (±3.089893)	49.82933 (±1.849638)	44.28631 (±1.909932)

Table XVIII: Repeated analysis of variance established for heart rate variability (rMSSD) (ms) with the factor condition without co-variates during driving condition (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Conditions	4308	2, 48	2154	2.533241	0.089971
time on task	3050	8, 192	381	10.13245	*9.15E-12
conditions*time on task	825	16, 384	52	1.39251	0.14161

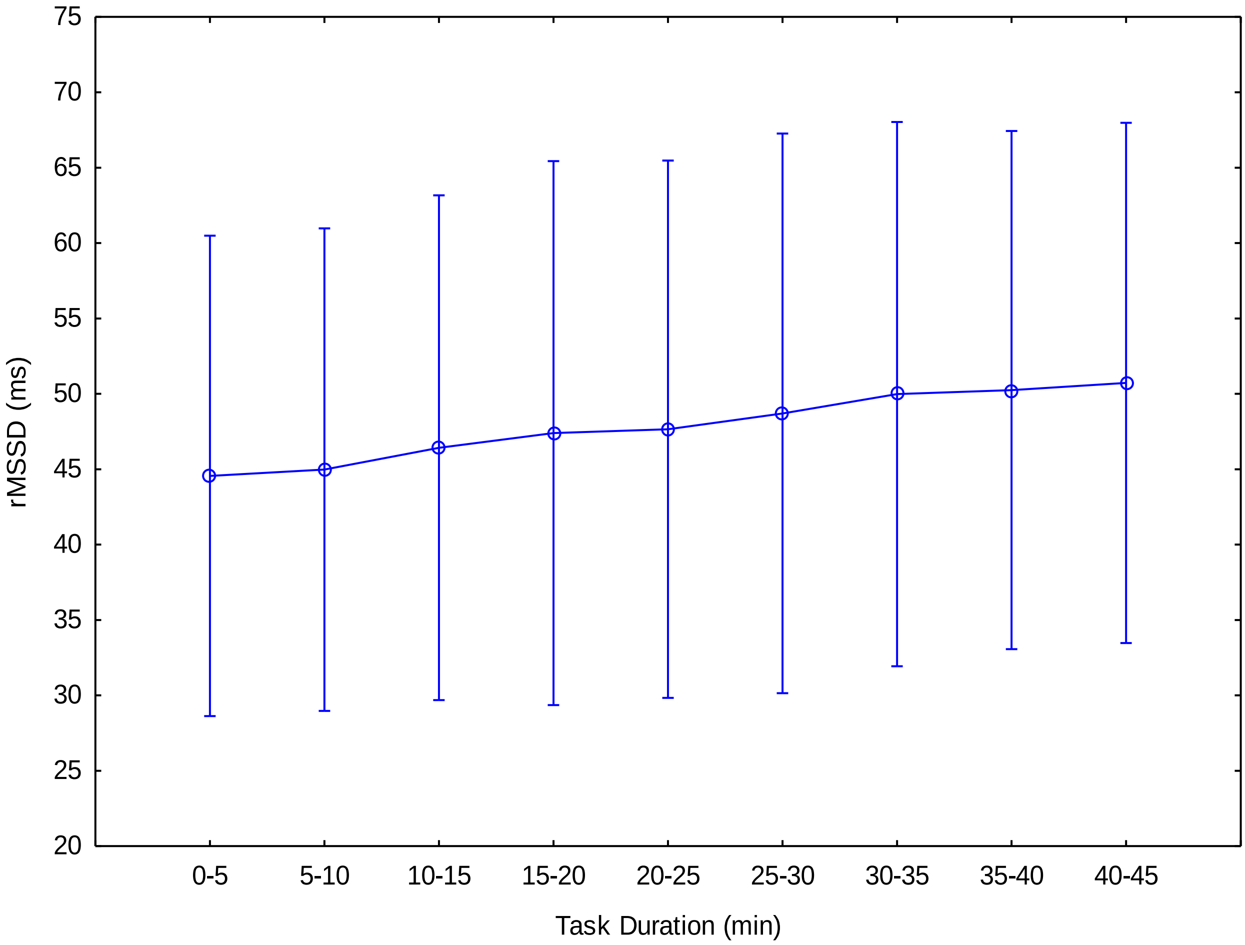

Figure 16: Heart rate variability (rMSSD) measured over the driving task, steadily increases, at $p<0.05$. Error bars denote the 95% confidence interval. Current effect $F(8, 192) = 10.13245$, $p = 9.15E-12$.

Effect of Personality Traits

Table XIX: Repeated analysis of variance for the heart rate variability rMSSD (ms) with the factor condition and all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, $p<0.05$).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	34879.18	1, 19	34879.18	1.97851	0.175694
Agreeableness	6331.264	1, 19	6331.26	0.359139	0.556064
Conscientiousness	199.3543	1, 19	199.35	0.011308	0.916427
Neuroticism	8.418043	1, 19	8.42	0.000478	0.982794
Openness	1352.719	1, 19	1352.72	0.076733	0.784766
Conditions	1493.218	2, 38	746.61	1.010484	0.373615
conditions*extraversion	7946.376	2, 38	3973.19	5.377436	0.008781
conditions*agreeableness	5579.971	2, 38	2789.99	3.776053	*0.031932
conditions*Conscientiousness	547.4735	2, 38	273.74	0.370484	0.692866

conditions*neuroticism	257.2218	2, 38	128.61	0.174066	0.840908
conditions*openness	2339.096	2, 38	1169.55	1.582902	0.218621
time on task	306.2857	8, 152	38.29	1.065213	0.390477
time on task*extraversion	145.8438	8, 152	18.23	0.507222	0.849559
time on task*agreeableness	298.4366	8, 152	37.30	1.037915	0.410151
time on task*conscientiousness	137.6461	8, 152	17.21	0.478711	0.869847
time on task*neuroticism	561.114	8, 152	70.14	1.951466	0.056288
time on task*openness	256.5725	8, 152	32.07	0.892319	0.524555
conditions*time on task	713.2334	16, 304	44.58	1.109785	0.344731
conditions*time on task*extraversion	389.5917	16, 304	24.35	0.606201	0.878563
conditions*time on task*agreeableness	415.136	16, 304	25.95	0.645948	0.845168
conditions*time on task*conscientiousness	369.8837	16, 304	23.12	0.575536	0.90147
conditions*time on task*neuroticism	781.0793	16,304	48.82	1.215353	0.254475
conditions*time on task*openness	256.4568	16, 304	16.03	0.399045	0.982276

The repeated analysis of variance calculated for the heart rate variability of rMSSD (ms) with the factors condition and all personality traits show that personality traits (extraversion, agreeableness, conscientiousness, neuroticism, and openness) produce no significant results on the heart rate variability rMSSD. The condition and personality trait (agreeableness) together have an effect on the heart rate variability rMSSD (ms) at a current effect of F= (2, 38) =3.776053, p=0.031932; (Table XIX). Agreeableness participants and the condition impacts the heart rate variability responses yielded in these particular personality traits. All three variables conditions, time on task and the personality traits collectively have no significant effect.

Effect of co-variates age and sex

Table XX: Repeated analysis of variance on heart rate variability rMSSD (ms) with the factors condition and co-variate age during the driving condition (without music, moderate music, loud music) (*= significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Age	218617.8	7, 17	31231.11	3.449968	*0.01745
Condition	3863.145	2, 34	1931.573	2.125268	0.134991
condition*Age	9914.766	2, 34	708.1976	0.779215	0.683174
time on task	1289.08	8, 136	161.1349	4.644167	*4.89E-05
time on task*Age	2504.931	56, 136	44.73092	1.289217	0.119346
condition*time on task	873.1351	16, 272	54.57094	1.435717	0.124464
condition*time on task*Age	3875.635	112, 272	34.60388	0.9104	0.713757

Table XXI: Repeated analysis of variance on the heart rate variability rMSSD (ms) with the factor condition and co-variate sex during the driving condition (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Sex	155.0169	1, 23	155.0169	0.009575	0.922896823
Condition	4631.81	2, 46	2315.905	2.883664	0.066091852
condition*Sex	3872.887	2, 46	1936.444	2.411175	0.100965014
time on task	2961.209	8, 184	370.1511	9.802203	*2.61E-11
time on task*Sex	275.4005	8, 184	34.42507	0.911632	0.508018918
condition*time on task	886.1379	16, 368	55.38362	1.493271	0.098968475
condition*time on task*Sex	565.5474	16, 368	35.34671	0.953029	0.508361645

SDNN

Effect of Condition

The mean and standard deviation of the heart rate variability of the SDNN show no conditional differences according to the inferential statistics. The repeated analysis of variance calculated for the heart rate variability (SDNN) (ms) with the factors condition but without co-variates show that there is no statistical significance for the condition variables on heart rate variability, but there is an effect on the time on task on the heart rate variability and this demonstrates a similar pattern like that of heart rate variability rMSSD (Figure 16). Increase in heart rate variability SDNN again reflects diminished alertness, and/or relaxed state of the participants. This also illustrates possible signs of fatigue. Heart rate variability was 35.61 (ms) from the start of the driving task and ended at 40.39 (ms) (Figure 17).

Table XXII: Mean and standard deviation (±) of the heart rate variability (SDNN) (ms) for the different conditions (n=25).

Without music	Moderate music	Loud music
39.50773 (±2.650669)	40.05408889 (±1.683991929)	35.33626667 (±2.130622611)

Table XXIII: Repeated analysis of variance for the condition effects on heart rate variability (SDNN) with the factor condition and without co-variates during the administered conditions (without music, moderate music, loud music) (*=significant effect, $p<0.05$).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Condition	2996.8	2, 48	1498.4	2.664294	0.079937
time on task	1752.3	8, 192	219.0	8.14132	*<0.01
condition*time on task	592.0923	16, 384	37.00577	1.402629	0.136697

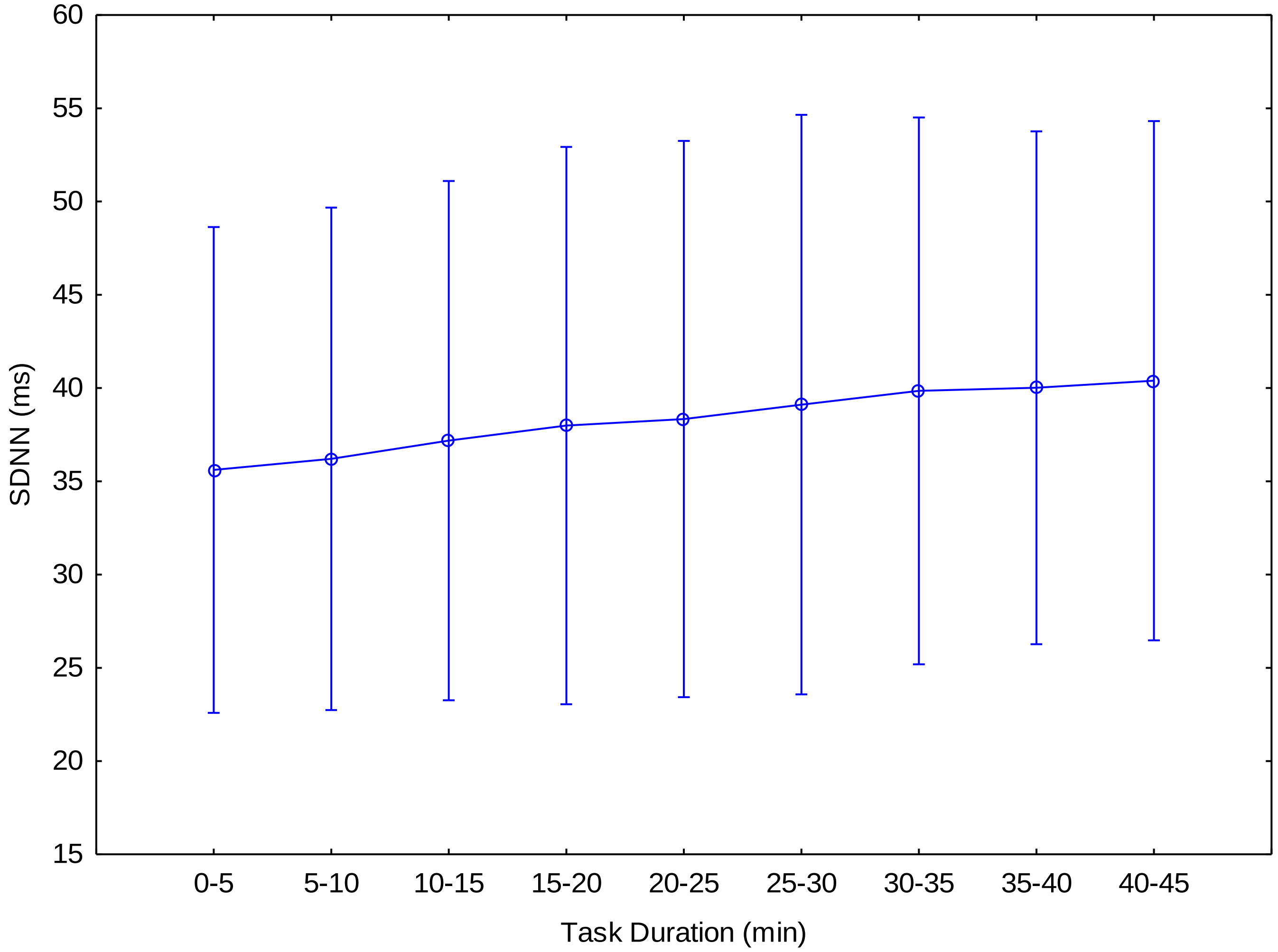

Figure 17: There is a gradual increase in heart rate variability (SDNN) from the start of the driving task to the end of the driving task (Error bars denote the 95% confidence interval).

Effect on Personality Traits

Table XXIV: The repeated analysis of variance on the heart rate variability SDNN (ms) with the factors conditions and all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, p< 0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	24043.29	1, 19	24043.29	2.04039	0.169404
Agreeableness	3136.186	1, 19	3136.186	0.266147	0.61188
Conscientiousness	5378.793	1, 19	5378.793	0.456461	0.507423
Neuroticism	4.266365	1, 19	4.266365	0.000362	0.985017
Openness	2107.086	1, 19	2107.086	0.178814	0.677142
Condition	459.7971	2, 38	229.8985	0.460355	0.634533
condition*extraversion	4849.639	2, 38	2424.819	4.85552	*0.013247
condition*agreeableness	3822.45	2, 38	1911.225	3.827085	*0.030603
condition*Conscientiousness	81.54446	2, 38	40.77223	0.081643	0.921762
condition*neuroticism	150.4267	2, 38	75.21337	0.150609	0.860695
condition*openness	1577.901	2, 38	788.9506	1.579815	0.219245
time on task	177.8416	8, 152	22.2302	0.888108	0.528069
time on task *extraversion	85.36864	8, 152	10.67108	0.426315	0.903879
time on task*agreeableness	225.9017	8, 152	28.23771	1.12811	0.34752
time on task*Conscientiousness	270.9772	8, 152	33.87215	1.353209	0.221617
time on task*neuroticism	432.6448	8, 152	54.0806	2.160547	*0.033518
time on task*openness	154.254	8, 152	19.28175	0.770316	0.629419
condition*time on task	689.9068	16, 304	43.11917	1.547441	0.08225
condition*time on task*extraversion	270.0532	16, 304	16.87832	0.605721	0.878941
condition*time on task*agreeableness	217.8788	16, 304	13.61743	0.488696	0.951879
condition*time on task*Conscientiousness	544.9069	16, 304	34.05668	1.22221	0.249246
condition*time on task*neuroticism	478.0482	16, 304	29.87801	1.072248	0.381079
condition*time on task*openness	182.8312	16, 304	11.42695	0.410085	0.979591

Extraversion and agreeableness together with the condition illustrate statistical significance on the heart rate variability SDNN (ms). With the interactional effect of condition and extraversion at a p=0.013247. There is statistical significant in the time on task and traits on heart rate variability: SDNN. The Table XXIV show the interactional relationship between the time on the task and neuroticism participants, indicating changes in HRV: SDNN for this personality trait as compared to the rest of the personality traits.

Effect of co-variates age and sex

Repeated analysis of variance run and calculated for the factors condition and co-variate age effect show no statistical significance on the heart rate variability SDNN (ms) (see Appendix E).

Table XXV: Repeated analysis of variance on the heart rate variability SDNN (ms) with the factor condition and co-variate sex (*significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Sex	227.7879	1, 23	227.7879	0.020762	0.886685273
Condition	3201.041	2, 46	1600.521	2.997453	0.059749168
condition*Sex	2433.148	2, 46	1216.574	2.278398	0.113893942
time on task	1684.459	8, 184	210.5573	7.832565	*4.87145E-09
condition*time on task	614.4165	16, 368	38.40103	1.460312	0.111607574
condition*time on task*Sex	454.0307	16, 368	28.37692	1.079116	0.373311569

Repeated analysis of variance on the heart rate variability SDNN (ms) showing no significance for the sex, condition, condition and sex, condition and time on task, condition, time on task, and sex.

PNN30%

Effect of Condition

Table XXVI: Mean and standard deviation (±) of the heart rate variability (PNN30%) for the different conditions (n=25).

Without music	Moderate music	Loud music
46.49163 (±1.103028)	45.609 (±1.285263)	43.85978 (±0.605496)

Mean and standard deviation values for the three conditions on heart rate variability PNN30% illustrate similarities in the values between each condition, with slight differences but no significance. Repeated analysis of variance for condition effects on the heart rate variability PNN30% without co-variates were run and calculated and there was no statistical significance between the condition and the heart rate variability PNN30% (see Appendix E).

Effect of Personality traits

Table XXVII: Repeated analysis of variance on heart rate variability PNN30% with the factor condition and all the personality traits during the driving condition (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	40171.14	1, 19	40171.14	5.465862	*0.030482
Agreeableness	20031.08	1, 19	20031.08	2.725516	0.115189
Conscientiousness	1770.303	1, 19	1770.303	0.240875	0.629195
Neuroticism	251.5559	1, 19	251.5559	0.034228	0.855184
Openness	889.9673	1, 19	889.9673	0.121093	0.731678
Condition	87.25325	2, 38	43.62663	0.046878	0.954259
condition*extraversion	2754.63	2, 38	1377.315	1.479974	0.240469
condition*agreeableness	6212.638	2,38	3106.319	3.33785	*0.046188
condition*Conscientiousness	609.0016	2, 38	304.5008	0.327197	0.722953
condition*neuroticism	2050.614	2 38	1025.307	1.101728	0.342676
condition*openness	2489.532	2, 38	1244.766	1.337545	0.274566
time on task	572.6656	8, 152	71.58321	3.042094	*0.003349
time on task*extraversion	155.7178	8, 152	19.46472	0.827198	0.579865
time on task*agreeableness	271.0273	8, 152	33.87841	1.439741	0.18427
time on task*Conscientiousness	150.9627	8, 152	18.87034	0.801939	0.601769
time on task*neuroticism	175.3059	8, 152	21.91324	0.931254	0.492546
time on task*openness	136.2236	8, 152	17.02794	0.723642	0.670429
condition*time on task	550.5206	16, 304	34.40754	1.624403	0.06138
condition*time on task*extraversion	266.0956	16, 304	16.63097	0.78516	0.70239
condition*time on task*agreeableness	287.0753	16, 304	17.9422	0.847064	0.631283
condition*time on task*Conscientiousness	388.7751	16, 304	24.29845	1.147146	0.310717
condition*time on task*neuroticism	379.0973	16, 304	23.69358	1.11859	0.336516
condition*time on task*openness	501.0319	16, 304	31.31449	1.478379	0.106007

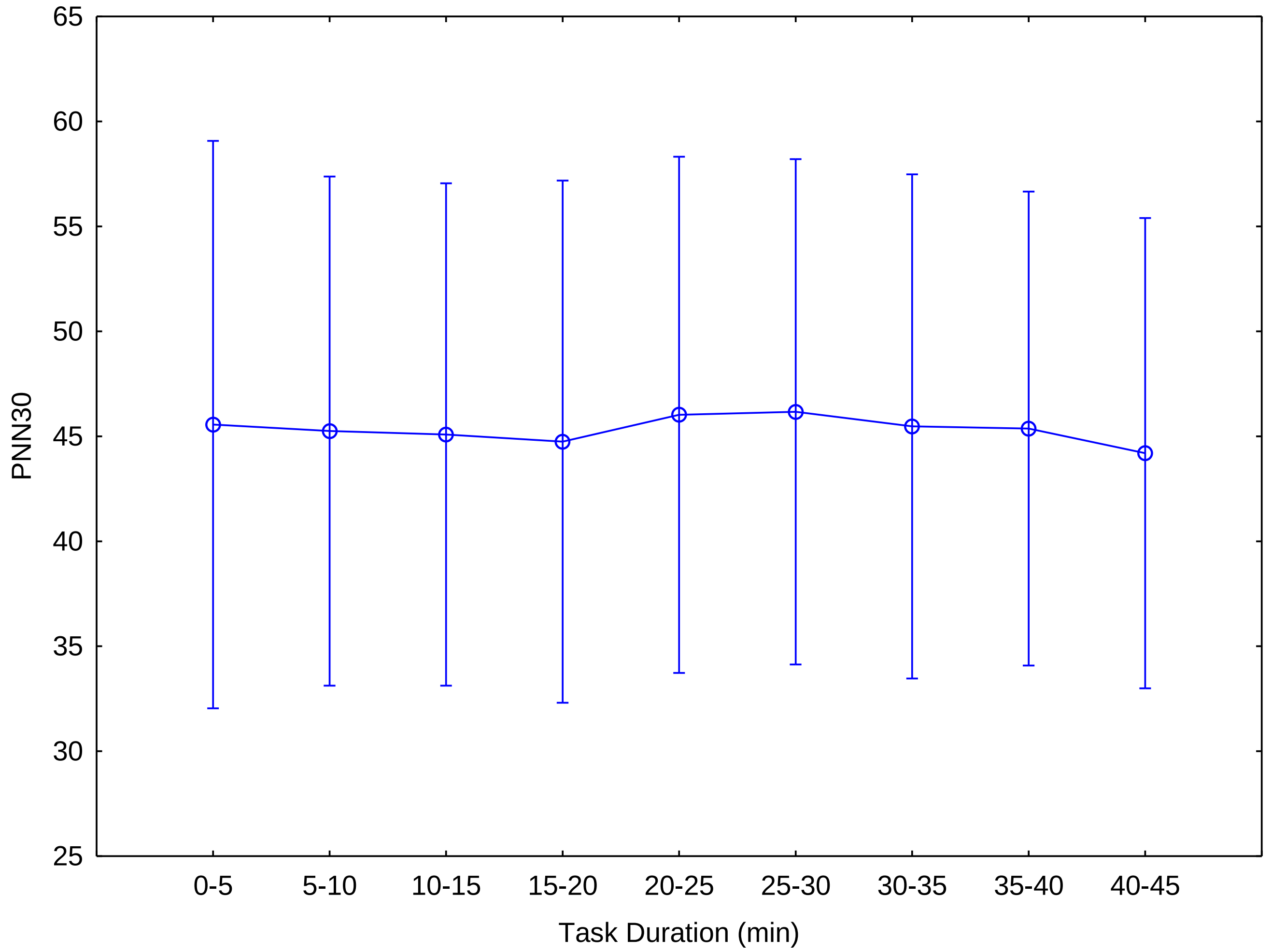

Figure 18: The heart rate variability (PNN30%) shows fluctuations throughout the driving task, with a gradual decrease, slight increase and a gradual decrease to the end of the driving task (Error bars denote the 95% confidence interval).

Effect of co-variate age and sex

The repeated measures analysis of variance on heart rate variability PNN30% with factors condition and co-variates the age and sex were calculated and yielded no significant results (see Appendix E).

PNN50%

Effect of Condition

Table XXVIII: Mean and standard deviation (±) of the heart rate variability (PNN50%) for the different conditions (n=25).

Without music	Moderate music	Loud music
26.31021289 (±1.54461851)	26.20284 (±0.793452)	23.58293 (±0.716877)

Repeated analysis of variance calculated for the condition effects without co-variates on heart rate variability PNN50% display no significant results (Appendix E).

Effect of Personality Traits

Table XXIX: Repeated analysis of variance on the heart rate variability PNN50% (ms) with factors condition and all personality traits during the driving conditions (without music, moderate music, loud music (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	40171.14	1, 19	40171.14	5.465862	*0.030482
Agreeableness	20031.08	1, 19	20031.08	2.725516	0.115189
Conscientiousness	1770.303	1, 19	1770.303	0.240875	0.629195
Neuroticism	251.5559	1, 19	251.5559	0.034228	0.855184
Openness	889.9673	1, 19	889.9673	0.121093	0.731678
Condition	87.25325	2, 38	43.62663	0.046878	0.954259
condition*extraversion	2754.63	2, 38	1377.315	1.479974	0.240469
condition*agreeableness	6212.638	2, 38	3106.319	3.33785	*0.046188
condition*Conscientiousness	609.0016	2, 38	304.5008	0.327197	0.722953
condition*neuroticism	2050.614	2, 38	1025.307	1.101728	0.342676
condition*openness	2489.532	2, 38	1244.766	1.337545	0.274566
time on task	572.6656	8, 152	71.58321	3.042094	*0.003349
time on task*extraversion	155.7178	8, 152	19.46472	0.827198	0.579865
time on task*agreeableness	271.0273	8, 152	33.87841	1.439741	0.18427
time on task*Conscientiousness	150.9627	8, 152	18.87034	0.801939	0.601769
time on task*neuroticism	175.3059	8, 152	21.91324	0.931254	0.492546
time on task*openness	136.2236	8, 152	17.02794	0.723642	0.670429
condition*time on task	550.5206	16, 304	34.40754	1.624403	0.06138
condition*time task*extraversion	266.0956	16, 304	16.63097	0.78516	0.70239
condition*time on task*agreeableness	287.0753	16, 304	17.9422	0.847064	0.631283
condition*time on task*Conscientiousness	388.7751	16, 304	24.29845	1.147146	0.310717
condition*time on task*neuroticism	379.0973	16, 304	23.69358	1.11859	0.336516
condition*time on task*openness	501.0319	16, 304	31.31449	1.478379	0.106007

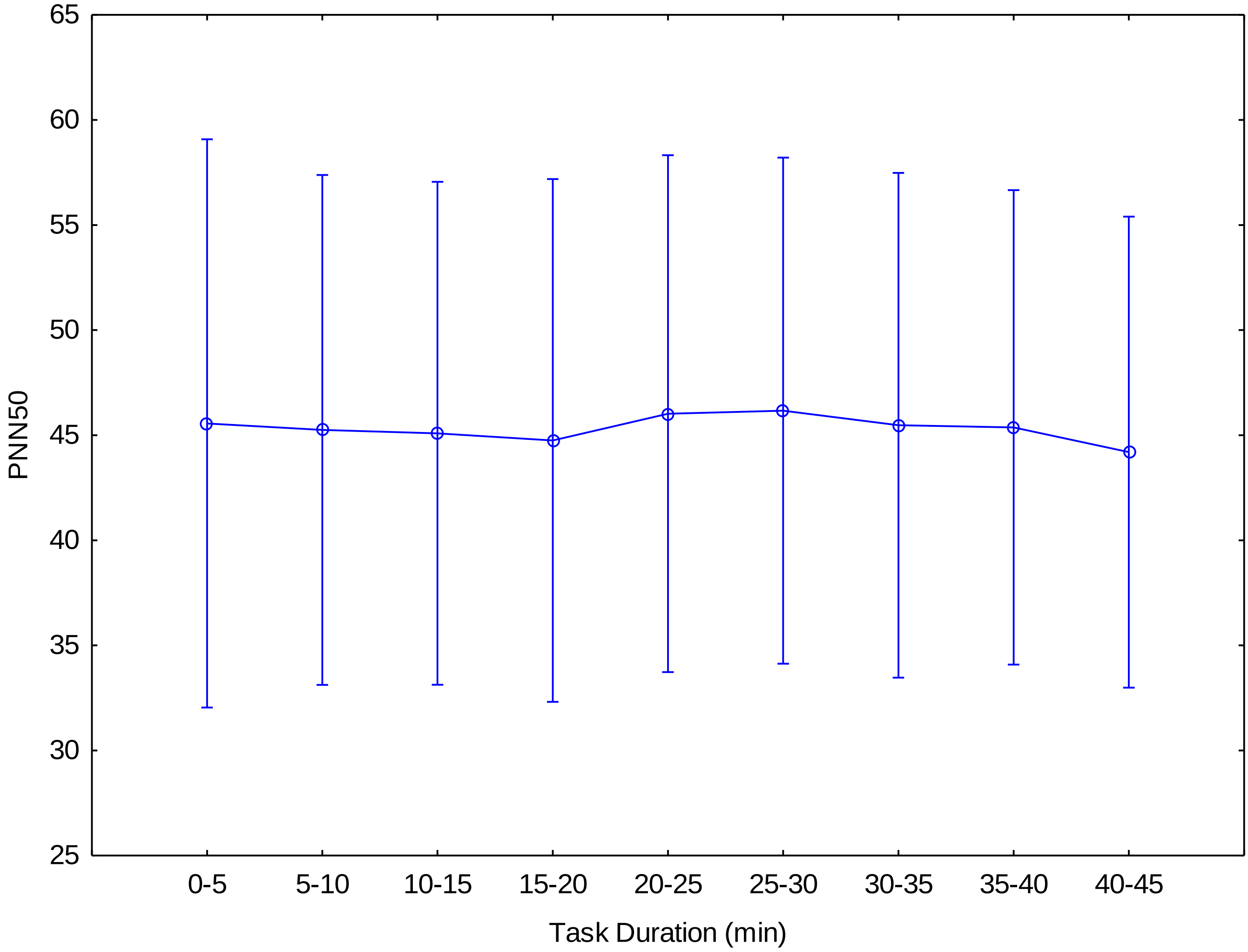

Figure 19: The heart rate variability (PNN50%) shows fluctuations throughout the driving task, with a gradual decrease, slight increase and a gradual decrease to the end of the driving task (Error bars denote the 95% confidence interval).

Repeated analysis of variance calculated for the factors condition and all personality traits during the driving task presented significance for the personality trait extraversion, an interactional effect between condition and agreeableness, and lastly a time on task effect. Figure 19 shows the gradual decrease in PNN50% which shows the same pattern in the other heart rate variability measures. The diminished alertness of participants between the start of the task up to the 15 minute of the driving task. Between the 15th minute and the 20th minute there was a slight fluctuation in HRV PNN50%.

Effect of co-variate age and sex

The repeated analysis of variance calculated for heart rate variability PNN50% with factors condition and co-variate age and sex variables do not display statistical significance (see Appendix E).

HF power (ms^2)

Effect of Condition

Table XXX: Mean and standard deviation (±) of the HF power (ms^2) for the different conditions (n=25).

Without music	Moderate music	Loud music
765.6361333 (±181.9887084)	844.9158 (±257.7736)	785.4684 (±1168.589)

The repeated analysis of variance showed that there is no statistical significance on the effect of condition without co-variates on HF power (ms^2), effect of personality traits nor effect of co-variate age and sex (see Appendix E).

HF centre frequency (Hz)

Effect of condition

Table XXXI: Mean and standard deviation (±) of the HF centre frequency (Hz) for the different conditions (n=25).

Without music	Moderate music	Loud music
0.257880444 (±0.001635496)	0.255896 (±0.002598)	0.262674 (±0.002923)

Table XXXII: Repeated analysis of variance on heart rate variability HF centre frequency (Hz) with factors condition during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Condition	0.005465	2	0.002733	1.317551	0.2773
time on task	0.012343	8	0.001543	8.416029	*8.8E-10
condition*time on task	0.002433	16	0.000152	0.977702	0.48046

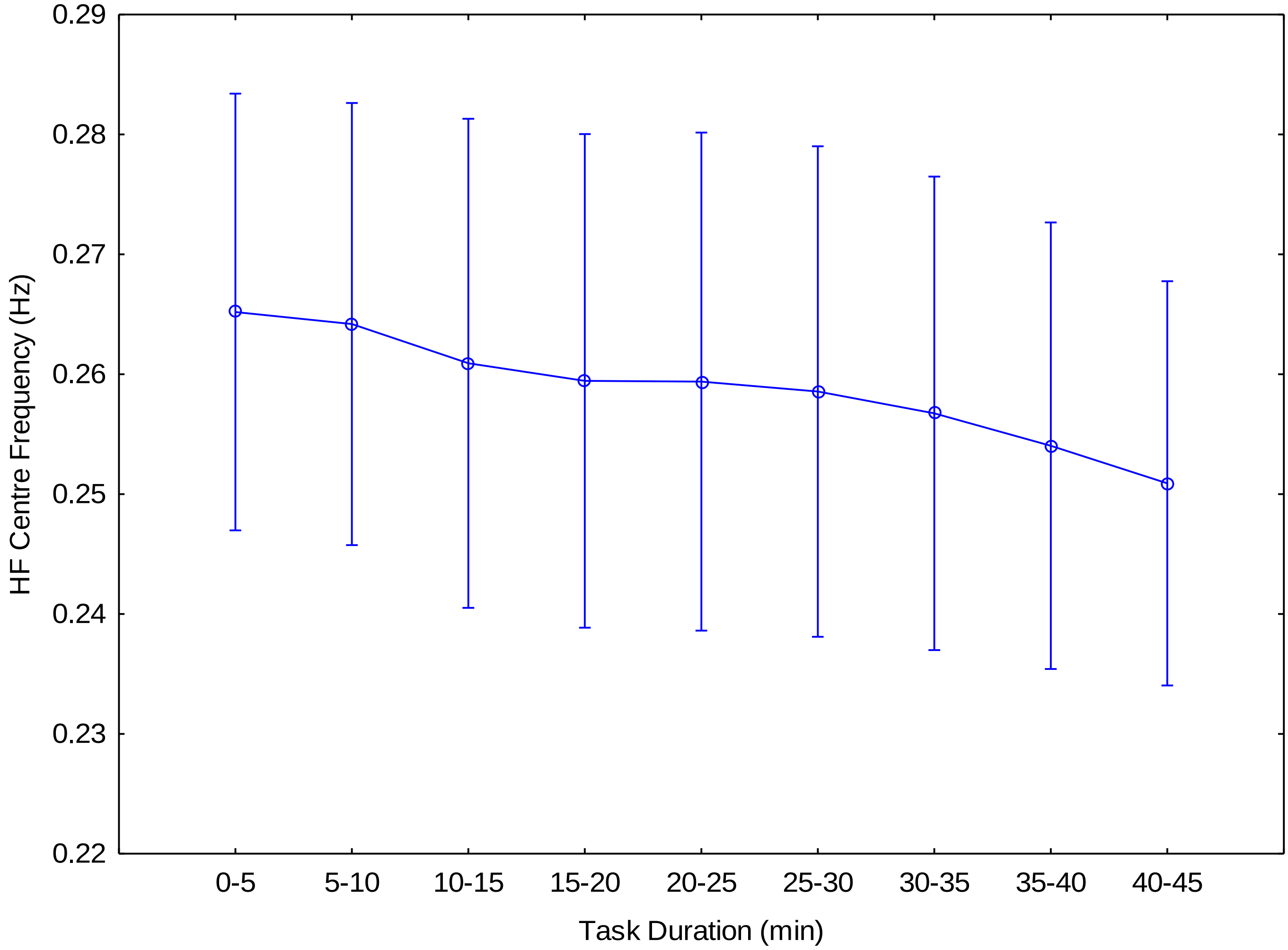

Figure 20: Decrease in HF centre frequency during the 45 minute driving task duration.

There is no statistical significance between the condition and the HF centre frequency (Hz). However, the HF centre frequency (Hz) is affected by the time on task, showing a gradual decrease in HF centre frequency.

Effect of Personality Traits

Table XXXIII: Repeated analysis of variance for heart rate variability for the factor condition and all personality traits during driving conditions (without music, moderate music, loud music) (*=significant effect, $p<0.05$).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Extraversion	0.048641	1, 19	0.048641	2.548547	0.126894
Agreeableness	0.000316	1, 19	0.000316	0.016549	0.898993
Conscientiousness	0.00565	1, 19	0.00565	0.296046	0.5927
Neuroticism	0.000713	1, 19	0.000713	0.037359	0.848787
Openness	0.000601	1, 19	0.000601	0.031482	0.861047
Condition	0.000118	2 , 38	5.92E-05	0.029781	0.970681
condition*extraversion	0.005202	2, 38	0.002601	1.308591	0.2821
condition*agreeableness	0.002941	2, 38	0.00147	0.739744	0.483982
condition*Conscientiousness	0.003094	2, 38	0.001547	0.778244	0.466392
condition*neuroticism	0.006627	2, 38	0.003313	1.667056	0.202314
condition*openness	0.000309	2, 38	0.000154	0.077667	0.925419
time on task	0.001715	8, 152	0.000214	1.361505	0.217786
time on task*extraversion	0.000861	8, 152	0.000108	0.683677	0.705423
time on task*agreeableness	0.001488	8, 152	0.000186	1.181446	0.31376
time on task*Conscientiousness	0.001155	8, 152	0.000144	0.917306	0.503908
time on task*neuroticism	0.001755	8, 152	0.000219	1.393281	0.20361
time on task*openness	0.003627	8, 152	0.000453	2.880452	*0.005159
condition*time on task	0.00514	16, 304	0.000321	2.383869	*0.002276
condition*time on task*extraversion	0.005092	16, 304	0.000318	2.3614	*0.002528
condition*time on task*agreeableness	0.008703	16, 304	0.000544	4.036503	*5.48E-07
condition*time on task*Conscientiousness	0.001219	16, 304	7.62E-05	0.565332	0.908513
condition*time on task*neuroticism	0.004336	16, 304	0.000271	2.010901	*0.012397
condition*time on task*openness	0.00185	16, 304	0.000116	0.857912	0.618655

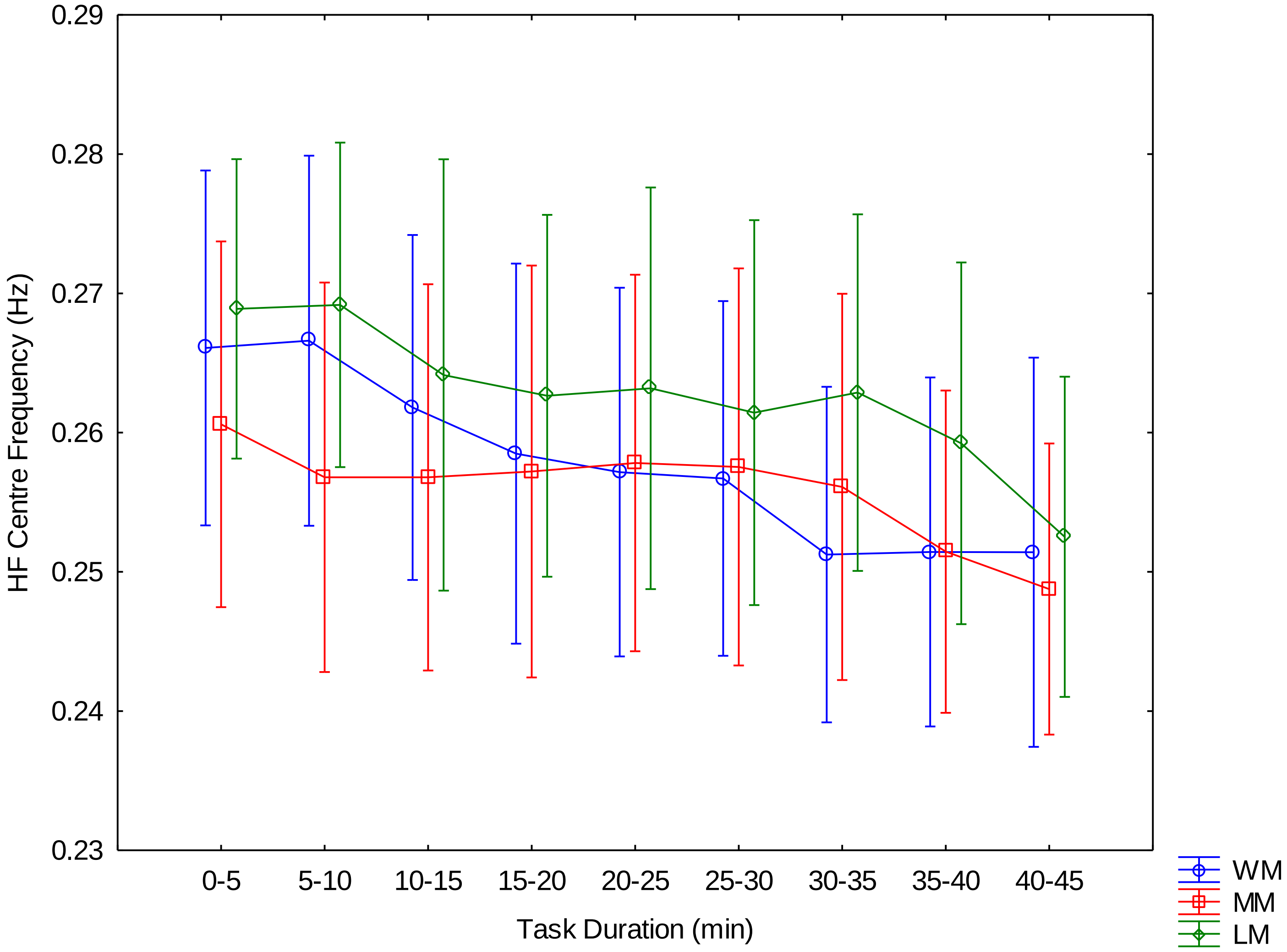

Figure 21: Time on task effect graph on the heart rate variability HF centre frequency showing differences in the three conditions. Gradual decrease of HF centre frequency throughout the 45 minute driving task for the three conditions.

Effect of co-variates age and sex

Table XXXIV: Repeated analysis of variance on the heart rate variability HF centre frequency (Hz) with the factors condition and co-variate age during driving conditions (without music, moderate music, loud music) (*=significant effect, $p<0.05$).

Factor	SS	dF	MS	F	p
Age	0.075331	1, 23	0.075331	4.733872	*0.040101
Condition	0.002841	2, 46	0.001421	0.672342	0.515456
condition*Age	0.002365	2, 46	0.001182	0.559603	0.575277
time on task	0.002469	8, 184	0.000309	1.704321	0.099885
time on task*Age	0.00188	8, 184	0.000235	1.297651	0.24711
condition*time on task	0.002166	16, 368	0.000135	0.866471	0.608711
condition*time on task*Age	0.002224	16, 368	0.000139	0.889474	0.581808

Table XXXV: Repeated analysis of variance on the heart rate variability HF centre frequency (Hz) with the factors conditions and co-variate sex during the driving conditions (without music, moderate music, loud music) (*=significant effect, $p<0.05$).

Factors	SS	dF	MS	F	p
sex	0.000453	1, 23	0.000453	0.023611	0.879218
Condition	0.005273	2, 46	0.002637	1.325669	0.275581
condition*Sex	0.008062	2, 46	0.004031	2.026698	0.14337
time on task	0.011877	8, 184	0.001485	8.040741	*2.77E-09
time on task*Sex	0.001225	8, 184	0.000153	0.829233	0.577849
condition*time on task	0.00244	16, 368	0.000153	0.972294	0.486607
condition*time on task*Sex	0.001991	16, 368	0.000124	0.793412	0.693375

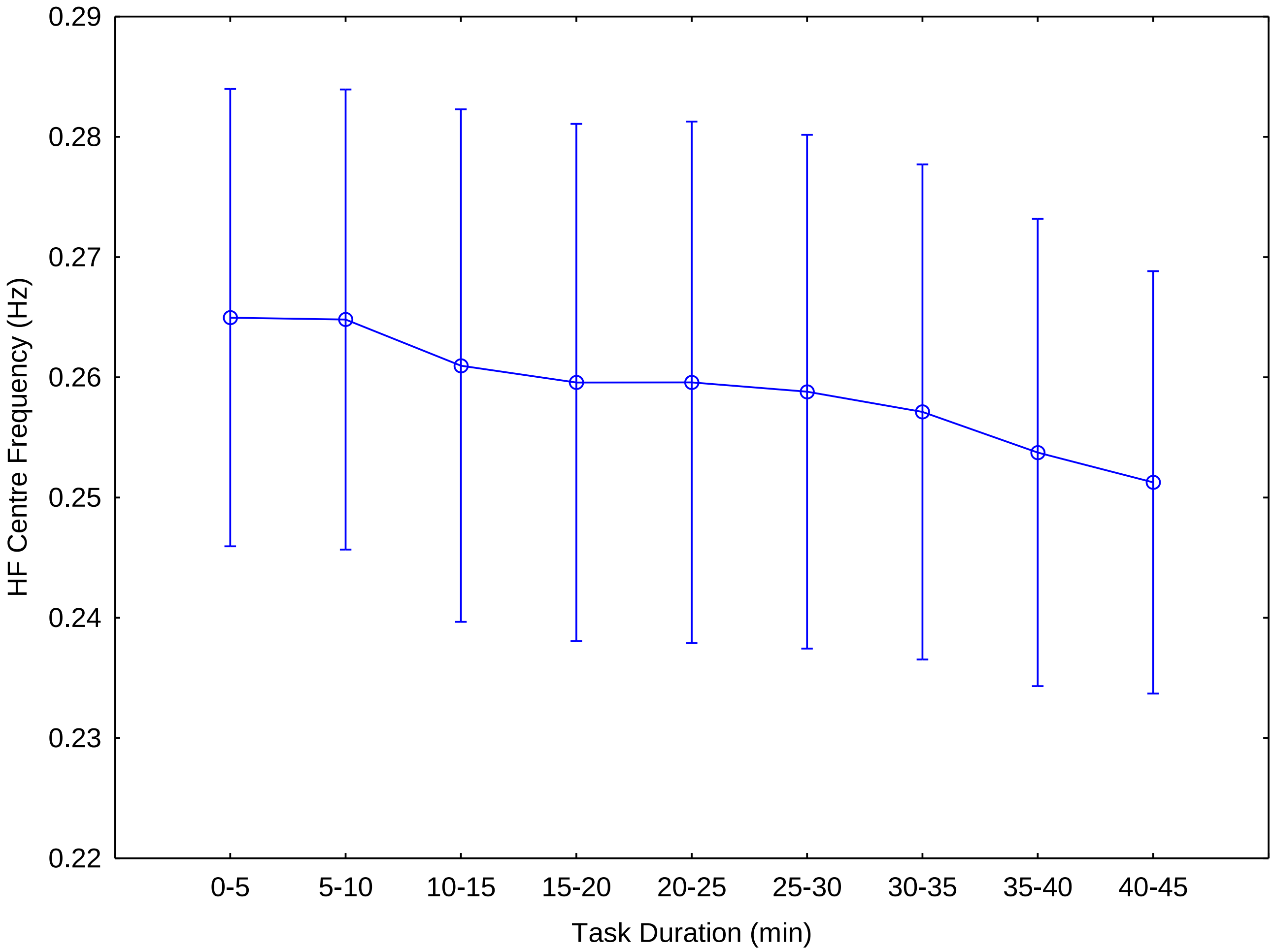

Figure 22: The change in HF centre frequency over time during the 45 minute driving task Current effect: F (8, 184) = 8.040741, p=*2.77E-09.

LF power

Effect of Condition

Mean and standard deviation values were calculated for the LF power of the different conditions and for each condition the tracking deviation are closely related; however, there is a vast variance amongst participants (Table XXXVI). Repeated analysis of variance calculated on the heart rate variability LF power with the factors conditions show that there is no statistical significance between condition and the LF power heart rate variability variable (Appendix E).

Table XXXVI: Mean and standard deviation (±) of the LF power for the different conditions (n=25).

Without music	Moderate music	Loud music
1424.803111 (±1548.852963)	1406.942 (±266.3356)	1602.27 (±3771.853)

Effect of Personality Traits

Repeated analysis of variance with the conditions and all personality traits on LF power yielded no statistical significance (Appendix E).

Effect of co-variate age and sex

The repeated analyses of variance were conducted on LF power and the factors condition with the co-variate age and sex and yielded no significant results (Appendix E).

LF centre Frequency

Effect on Condition

Table XXXVII: Mean and standard deviation (±) of the LF centre frequency (Hz) for the different conditions (n=25).

Without music	Moderate music	Loud music
0.089455689 (±0.000539059)	0.090679 (±0.000601)	0.088773 (±0.00102)

Table XXXVIII: Repeated analysis of variance on the heart rate variability LF centre frequency (Hz) with the factor condition and without co-variates during the driving conditions (without music, moderate music, loud music) (*=significant effect, $p<0.05$).

Factor	**SS**	**dF**	**MS**	**F**	**p**
Condition	0.00042	2, 48	0.00021	1.631803	0.206239
time on task	0.000473	8, 192	5.91E-05	2.391594	*0.017649
condition*time on task	0.000212	16, 384	1.32E-05	0.495655	0.949104

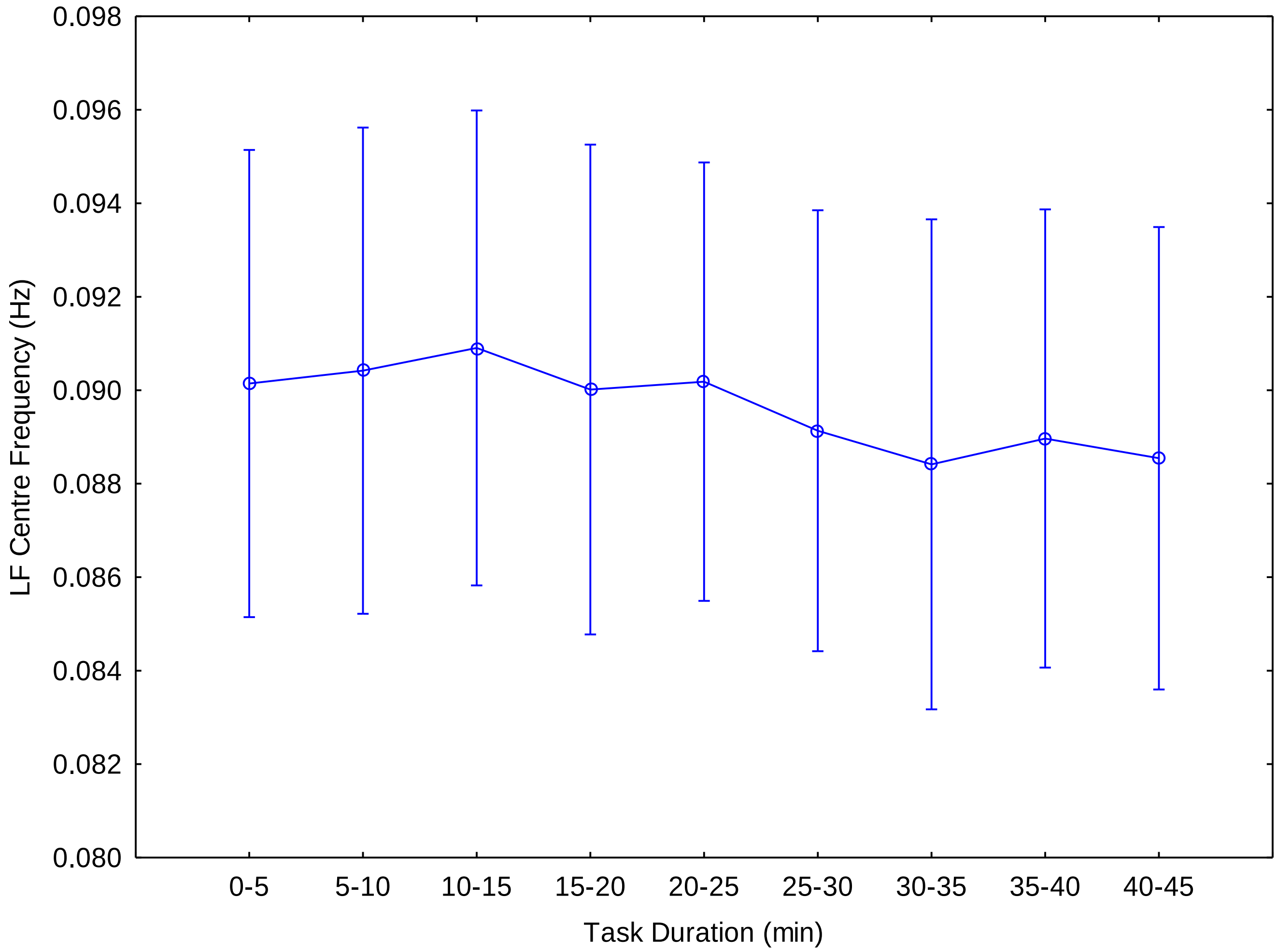

Figure 23: Change in LF Centre frequency (Hz) throughout the 45 minute driving duration task shows a gradual fluctuation and then decrease. Error bars represent the 95% confidence interval. Current effect: F (8, 192) =2.3916, p=0.01765.

Effect on Personality Traits

Table XXXIX: Repeated analysis of variance on the heart rate variability LF centre frequency (Hz) with the factors condition and all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, $p<0.05$).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	0.000994	1, 19	0.000994	1.134624	0.300141
Agreeableness	0.000638	1, 19	0.000638	0.728531	0.403992
Conscientiousness	0.00043	1, 19	0.00043	0.491003	0.491973
Neuroticism	0.00775	1, 19	0.00775	8.849348	*0.007784
Openness	0.000102	1, 19	0.000102	0.116016	0.737134
Condition	0.000528	2, 38	0.000264	2.173089	0.127767
condition*extraversion	0.00014	2, 38	6.98E-05	0.574482	0.56781
condition*agreeableness	0.000898	2, 38	0.000449	3.696775	*0.034119
condition*Conscientiousness	0.000168	2, 38	8.42E-05	0.693178	0.506195
condition*neuroticism	0.000107	2, 38	5.37E-05	0.442078	0.645963
condition*openness	9.39E-05	2, 38	4.7E-05	0.386788	0.681878
time on task	0.000186	8, 152	2.33E-05	0.879383	0.535381
time on task*extraversion	5.18E-05	8, 152	6.48E-06	0.244563	0.981554
time on task*agreeableness	0.000191	8, 152	2.39E-05	0.901389	0.517018
time on task*Conscientiousness	0.000253	8, 152	3.16E-05	1.191379	0.307745
time on task*neuroticism	0.000196	8, 152	2.46E-05	0.926508	0.496398
time on task*openness	0.000126	8, 152	1.57E-05	0.593002	0.782585
condition*time on task	0.000293	16, 304	1.83E-05	0.699565	0.794242
condition*time on task*extraversion	0.000555	16, 304	3.47E-05	1.325957	0.179471
condition*time on task*agreeableness	0.000741	16, 304	4.63E-05	1.770126	*0.034373
condition*time on task*Conscientiousness	0.00033	16, 304	2.06E-05	0.787382	0.699883
condition*time on task*neuroticism	0.000388	16, 304	2.43E-05	0.927419	0.537963
condition*time on task*openness	0.000468	16, 304	2.92E-05	1.116814	0.338163

Effect of co-variate age and sex

Repeated analysis variance for age on LF centre frequency (Hz) was conducted and it showed no statistical significance (Appendix E).

Table XL: Repeated analysis of variance on the heart rate variability LF centre frequency (Hz) with the factors conditions and co-variate sex during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Sex	0.00204	1, 23	0.00204	1.878399	0.183745
Condition	0.000354	2, 46	0.000177		
condition*Sex	4.22E-05	2, 46	2.11E-05	1.328299	0.274897
time on task	0.000462	8, 184	5.77E-05	2.269	*0.024488
time on task*Sex	6.42E-05	8, 184	8.03E-06	0.315713	0.959397
condition*time on task	0.000234	16, 368	1.46E-05	0.545873	0.921609
condition*time on task*Sex	0.000378	16, 368	2.36E-05	0.881645	0.590959

LF power relative to (LF+HF)

Effect of condition

Table XLI: Mean and standard deviation (±) of the LF power relative to (LF+HF) for the different conditions (n=25).

Without music	Moderate music	Loud music
63.31253 (±1.143243)	63.87533 (±1.159984)	63.23987 (±0.856951)

The mean and standard deviation were calculated and the repeated analysis of variance were calculated demonstrating no significance in the condition effect on the LF power to relative (LF+HF) (Table XLI).

Table XLII: Repeated analysis of variance on the heart rate variability LF power relative to (LF+HF) with the factors conditions without co-variates on driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Condition	54.43816	2, 48	27.21908	0.061278	0.940635
time on task	1689.158	8, 192	211.1448	3.682914	*0.000507
condition*time on task	743.4928	16, 384	46.4683	0.928242	0.536708

Table XLII show that there is a time on task effect on the LF power relative to (LF+HF) ratio but there is no significance on the interactional effect between condition and time on task on LF power relative to (LF+HF).

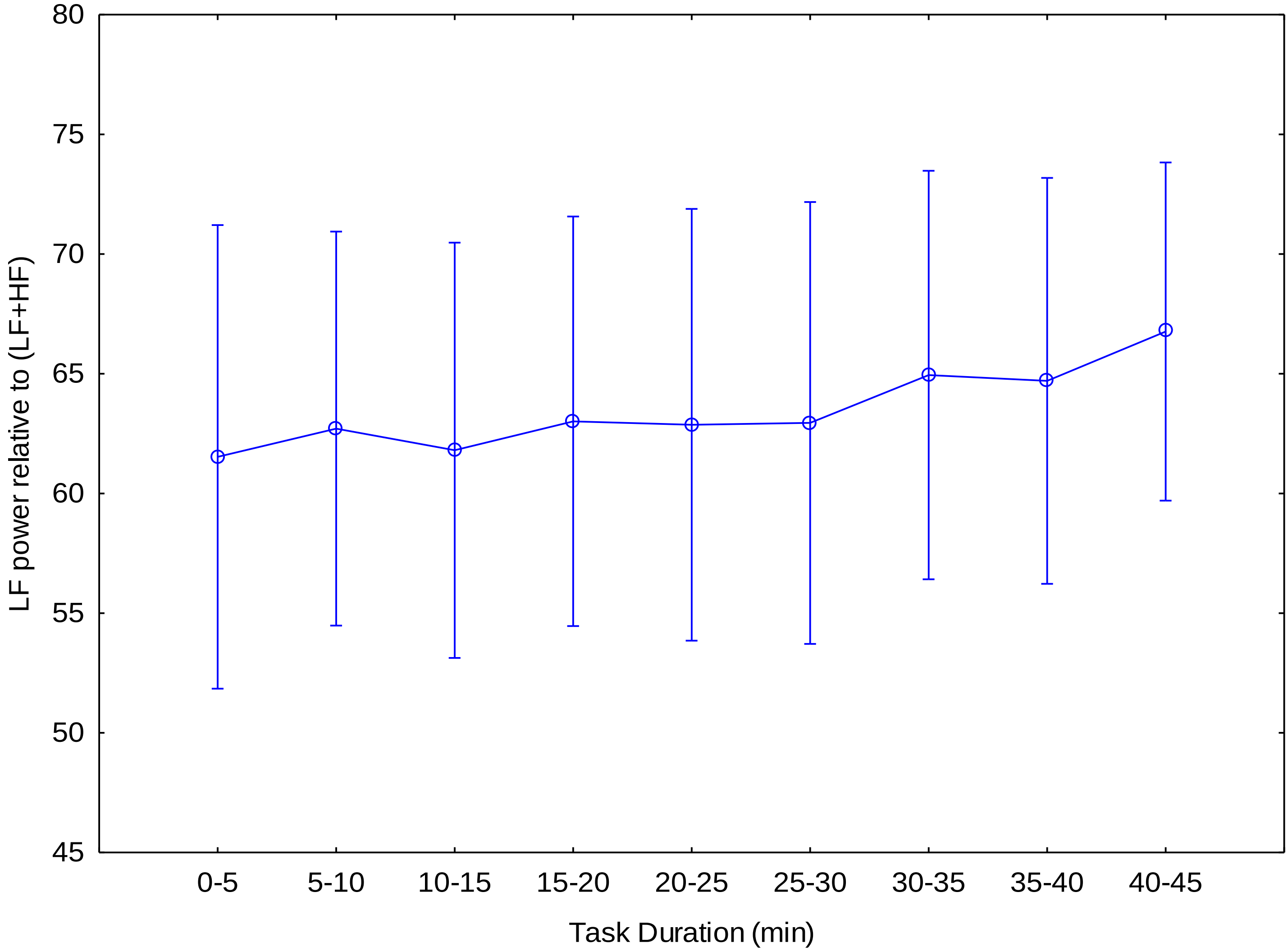

Figure 24: Change in LF power relative to (LF+HF) throughout the 45 minute driving duration task. Error bars represent the 95% confidence interval.

Effect of Personality Traits

Repeated analysis of variance on the condition and personality traits on the LF power relative to (LF+HF) demonstrates no statistical significance (Appendix E).

Effect of co-variate age and sex

The repeated analysis of variance on the factors condition and co-variate age prove that the no significant effect on LF power relative to (LF+HF) (Appendix E).

Table XLIII: Repeated analysis of variance on the heart rate variability LF power relative to (LF+HF) with the factors conditions and co-variate sex during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Sex	453.8549	1, 23	453.8549	0.125692	0.726171
Condition	58.94747	2, 46	29.47373	0.065578	0.936614
condition*sex	646.5622	2, 46	323.2811	0.719286	0.492497
time on task	1854.618	8, 184	231.8272	3.995958	*0.000216
time on task*sex	332.6926	8, 184	41.58657	0.716819	0.676505
condition*time on task	685.0733	16, 368	42.81708	0.85432	0.622921
condition*time on task*Sex	779.6997	16, 368	48.73123	0.972323	0.486574

The repeated analysis of variance on the heart rate variability LF power relative to (LF+HF) display that sex has no effect on LF power relative to (LF+HF), nor the interactional effect about condition and sex, time on task and sex, condition and time on task and lastly condition, time on task and sex. However, there is a time on task effect as illustrated previously.

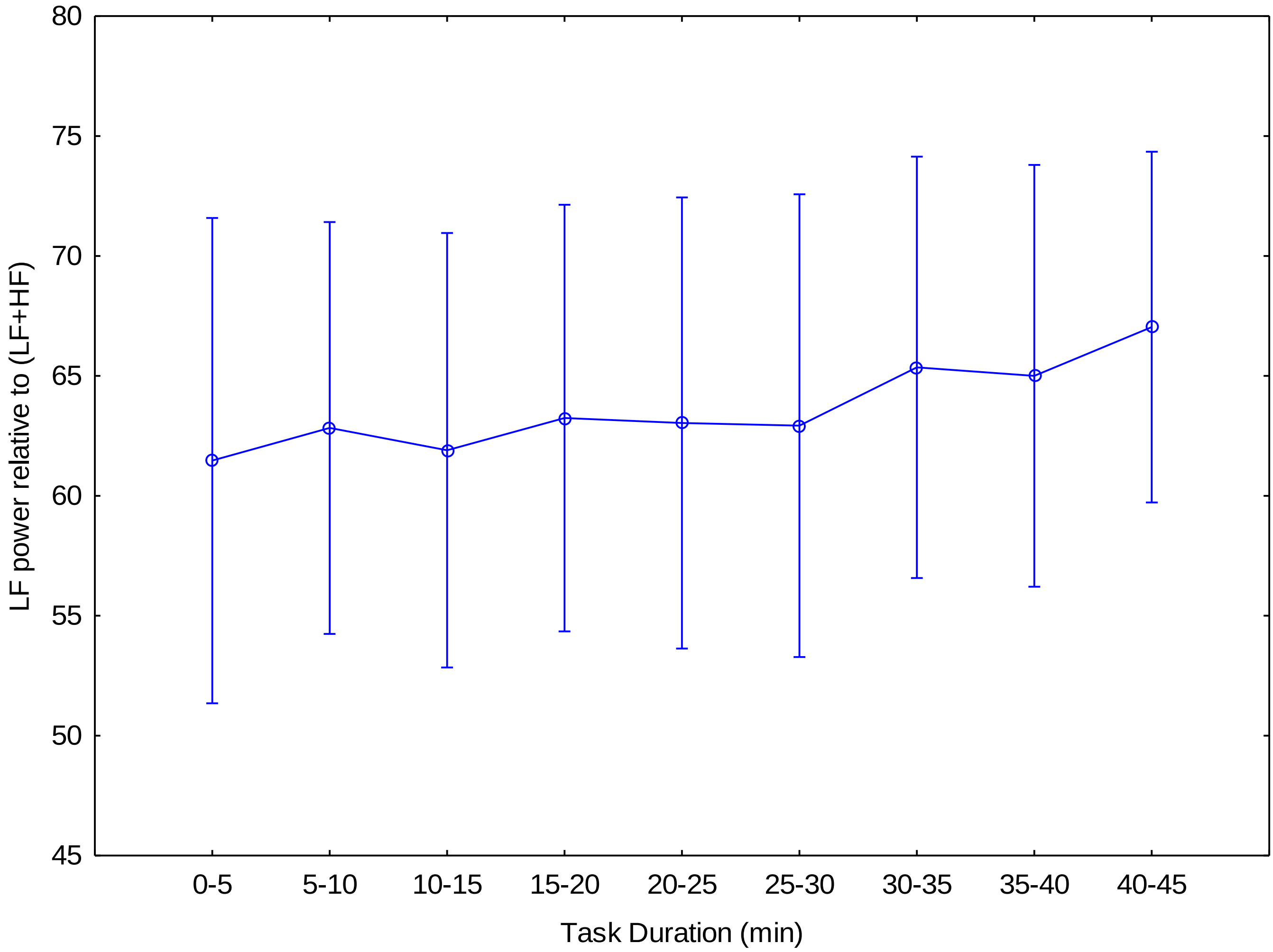

Figure 25: Change in LF power relative to (LF+HF) throughout the 45 minute driving duration task. The change shows a fluctuation throughout the driving test. Error bars represent the 95% confidence interval.

4.4 OCULOMOTOR PARAMETERS

Pupil Diameter

Effect on Condition

The mean and standard deviation of the pupil diameter (mm) on the different condition (Table XLIV) indicates that loud music shows the highest pupil diameter, second to that is the moderate music, and least score is the without music condition. Repeated analysis of variance conducted on pupil diameter reveals that there is a significant effect of conditions on the pupil diameter (mm). The pupil diameter (mm) increases the increase in sound intensity (Table XLV). Further analyses using the Fischer LSD Post Hoc illustrate differences between conditions on pupil diameter (Table XLVI).

Table XLIV: Mean and standard deviation (±) of the pupil diameter (m) for the different conditions (n=25).

Without music	Moderate music	Loud music
5.56 (±0.05)	5.58 (±0.05)	5.87 (±0.95)

Table XLV: Repeated analysis of variance on pupil diameter with the factors condition without co-variates during the driving condition (without music, moderate music, loud music) (*=significant effect, $p<0.05$). Current effect: $F(2, 46) = 6.158$, $p=0.004269$.

Factors	**SS**	**dF**	**MS**	**F**	**P**
Condition	15.12284	2, 46	7.56142	6.158056	*0.004269
time on task	0.638659	8, 184	0.079832	1.219964	0.289452
condition*time on task	0.46	16, 368	0.03	1.299	0.194536

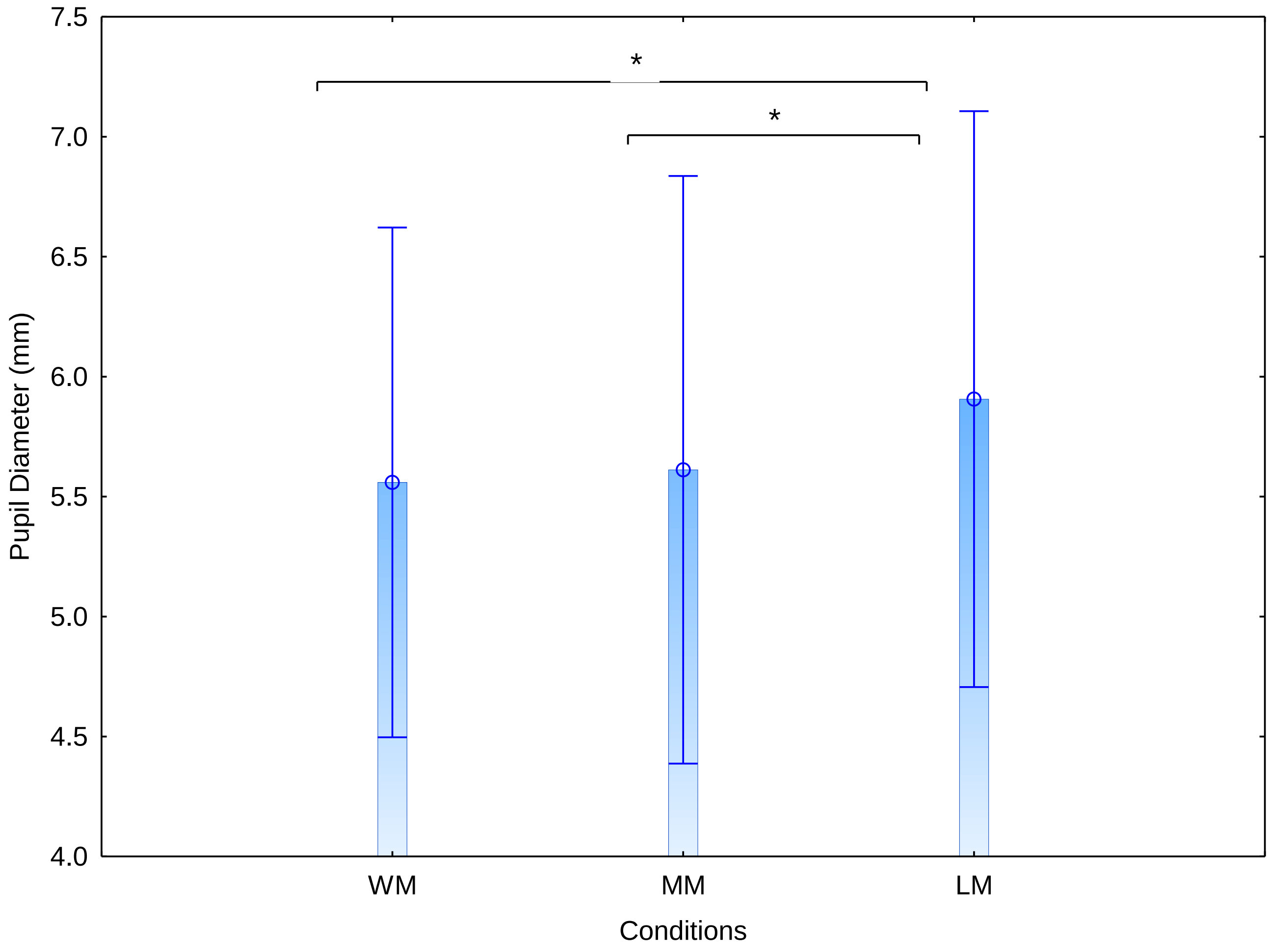

Figure 26: The pupil diameter (mm) increases over the three conditions (without music, moderate music, loud music) (Error bars denote 95% confidence interval).

Table XLVI: Post Hoc Fischer LSD showing the differences between the conditions for pupil diameter (mm) (*=significance, p<0.05).

CONDITIONS	Without music	Moderate music	Loud music
Without music		0.407644	0.003027
Moderate music	0.407644		0.026341
Loud music	0.003027	0.026341	

The Table XLVI Post Hoc Fischer LSD showing the differences between the conditions for pupil diameter (mm) (*=significance, p<0.05). Post Hoc Fischer LSD showing the differences between the conditions for pupil diameter (mm) (*=significance, p<0.05). Post Hoc Fischer LSD showing the differences between the conditions for pupil diameter (mm) (*=significance, p<0.05). Fischer LSD

Post Hoc shows that there are differences between the without music and loud music condition with p=0.003027 and there are differences between moderate music and loud music at p=0.026341, but no differences between without music and moderate music on pupil diameter.

Effect of Personality Traits

Table XLVII: The repeated analysis of variance on the pupil diameter (mm) with the factors conditions all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Extraversion	13.79144	1, 18	13.79144	0.717972	0.407936
Agreeableness	139.2837	1, 18	139.2837	7.251005	*0.014878
Conscientiousness	0.115833	1, 18	0.115833	0.00603	0.93896
Neuroticism	29.5283	1, 18	29.5283	1.537221	0.230953
Openness	3.82598	1, 18	3.82598	0.199178	0.660708
condition*extraversion	0.445955	2, 36	0.222978	0.176705	0.83875
condition*agreeableness	3.034445	2, 36	1.517222	1.202364	0.312263
condition*conscientiousness	7.293224	2, 36	3.646612	2.889856	0.068559
condition*neuroticism	0.686754	2, 36	0.343377	0.272118	0.763317
condition*openness	5.012309	2, 36	2.506154	1.986069	0.151989
time on task	0.078515	9, 162	0.008724	0.126032	0.998991
time on task*extraversion	0.515951	9, 162	0.057328	0.828204	0.591055
time on task*agreeableness	0.182387	9, 162	0.020265	0.292767	0.975963
time on task*conscientiousness	0.16077	9, 162	0.017863	0.258068	0.984518
time on task*neuroticism	0.136091	9, 162	0.015121	0.218454	0.991528
time on task*openness	0.150576	9, 162	0.016731	0.241704	0.987751
condition*time on task	0.531143	18, 324	0.029508	1.354321	0.152484
condition*time on task*extraversion	0.155208	18, 324	0.008623	0.395752	0.988144
condition*time on task*agreeableness	0.670806	18, 324	0.037267	1.710435	*0.036214
condition*conscientiousness	0.260251	18, 324	0.014458	0.663595	0.846354
condition*time on task*neuroticism	0.151171	18, 324	0.008398	0.385459	0.989842
condition*time on task*openness	0.36074	18, 324	0.020041	0.919823	0.554727

The repeated analysis of variance with the factors condition and all the personality traits show that of all the traits only the personality trait agreeableness showed statistical significance, demonstrating that agreeableness personality types were affected by the conditions as well as the time on the task, subsequently affecting the pupil diameter (mm).

Effect of co-variate age and sex

Repeated analysis of variance conducted with the factors conditions and co-variate age showed that there was no statistical significance between age and the pupil diameter (Appendix E).

Table XLVIII: The repeated analysis of variance on the relationship between the condition and the factor co-variate sex on pupil diameter (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Sex	54.07706	1, 22	54.07706	2.871484	0.104273
Condition	16.33408	2, 44	8.167042	6.630195	*0.003042
condition*sex	2.283991	2, 44	1.141995	0.927098	0.403291
time on task	0.671438	8, 176	0.08393	1.234777	0.281301
time on task*Sex	0.077645	8, 176	0.009706	0.14279	0.99704
condition*time on task	0.505311	16, 352	0.031582	1.416586	0.130791
condition*time on task*sex	0.363159	16, 352	0.022697	1.018078	0.436496

Saccades velocity: Eye speeds

Effect of Condition

Table XLIX: Mean and standard deviation (±) of the eye speeds for the different conditions (n=25).

Without music	Moderate music	Loud music
6.5325 (± 2.6962505)	8.143333 (± 5.670797)	5.3616 (± 0.143654)

The mean and standard deviation of the eye speeds were calculated and tabulated for each condition. The repeated analyses of variance statistics were run and calculated, and it was found that eye speeds was not affected by any of the dependent variables. All the statistical tables can be found in (Appendix E).

Fixation duration

Effect of Condition

Table L: Mean and standard deviation (±) of the fixation duration for the different conditions (n=25).

Without music	Moderate music	Loud music
0.160092593 (±0.000793719)	0.165968 (±0.001226)	0.164123 (±0.00123)

Table LI: The repeated analysis of variance on fixation duration with the factor condition without co-variates during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Condition	0.00374	2, 46	0.001869	0.372804	0.690862
time on task	0.00501	8, 184	0.000627	7.392469	*1.61E-08
condition*time on task	0.00286	16, 368	0.000178	2.542596	*0.000981

There is no statistical significance of the condition on the fixation duration. There is a statistical significance on time on task for the fixation duration at current effect 8, 184, 7.392469, p=1.161E-08. There is an interactional significant effect between condition and time on task on the fixation duration.

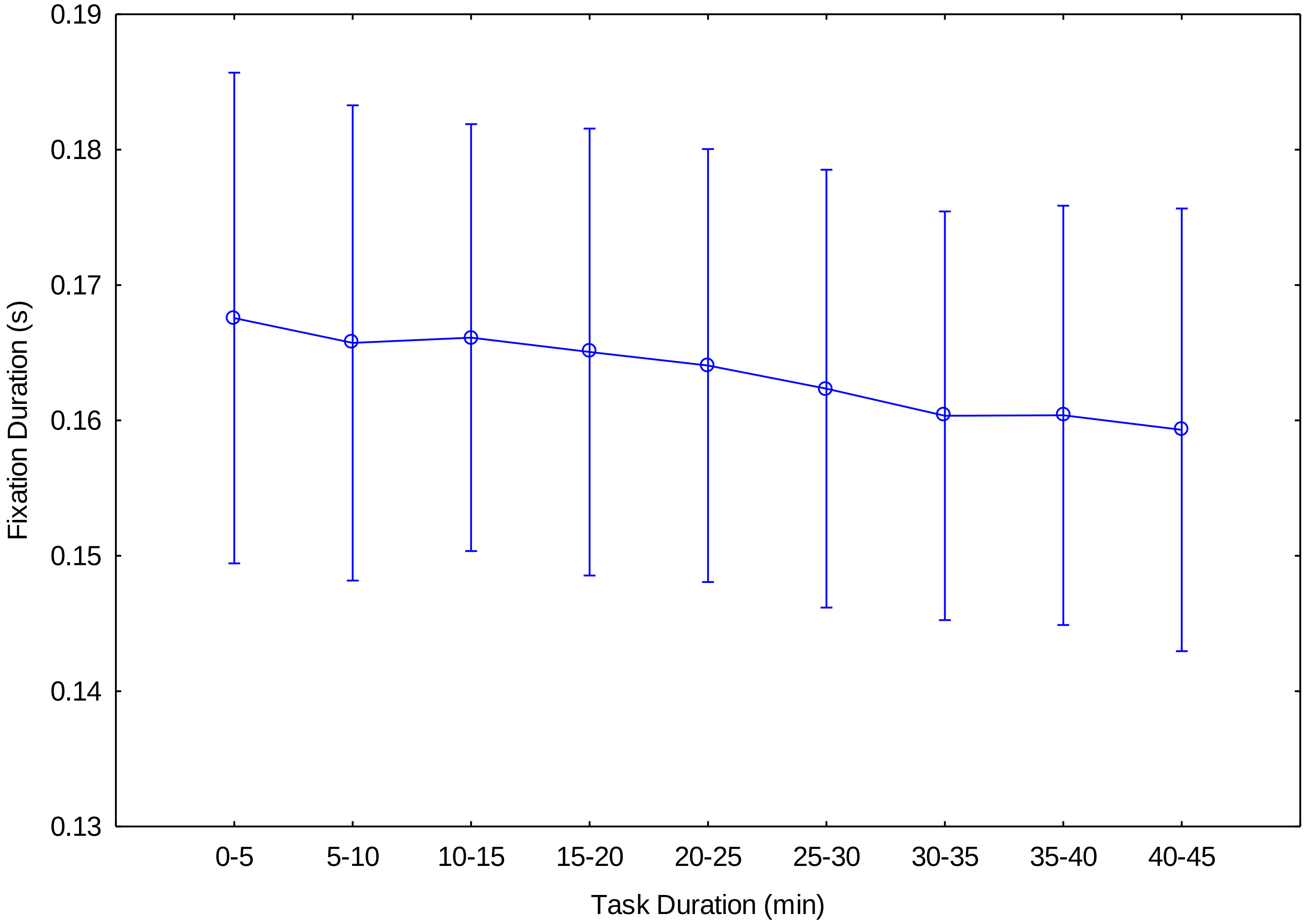

Figure 27: Change in fixation duration (s) measured over the 45 minute task duration for all participants. The error bars denote the 95% confidence interval.

There is a gradual decline of the fixation duration (s) from the beginning of the drive at 0.167564 (s) to 0.159304 (s) by the end the 45 minute task duration.

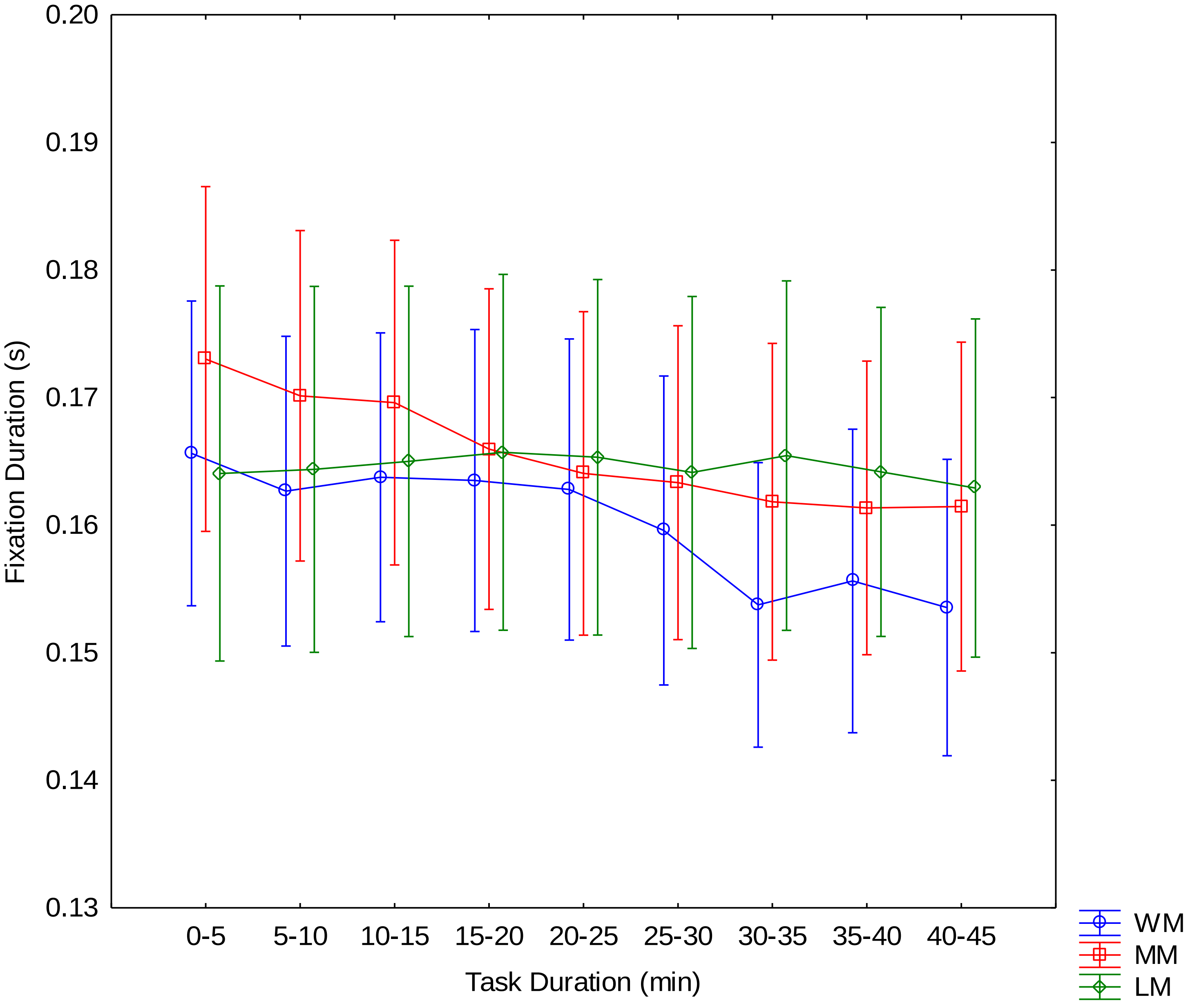

Figure 28: Fixation duration (s) measured over the 45 minute task duration for all participants. The error bars denote the 0.95 confidence interval. There are differences between the different conditions for all participants.

Effect on Personality Traits

There is no statistical significance of the personality traits on fixation duration see (Appendix E).

Effect of co-variate age and sex

Table LII: The repeated analysis of variance on the fixation duration with the factors conditions and co-variate age during the driving condition (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	SS	dF	MS	F	P
Age	0.004016	1, 22	0.004016	0.303331	0.587351
Condition	0.008923	2, 44	0.004462	0.884091	0.420299
condition*age	0.008608	2, 44	0.004304	0.852905	0.4331
time on task	0.001492	8, 176	0.000187	2.27233	*0.024511
condition*time on task	0.00212	16, 352	0.000132	1.986492	*0.013346

Table LII, demonstrate that there is no age, condition, and condition and age effect on the fixation duration. However, there is time on task effect and a condition and time on task effect on fixation duration.

Table LIII: The repeated analysis of variance on the fixation duration with the factors conditions and co-variate sex during driving conditions administered (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	SS	dF	MS	F	p
Sex	0.006935	1, 22	0.006935	0.529153	0.474634
Condition	0.00393	2, 44	0.001965	0.387968	0.680732
condition*sex	0.007793	2, 44	0.003896	0.769272	0.469481
time on task	0.004819	8, 176	0.000602	6.952058	*6E-08
time on task*sex	0.00035	8, 176	4.38E-05	0.504986	0.851499
condition*time on task	0.003039	16, 352	0.00019	2.651523	*0.000586
condition*time on task*sex	0.000617	16, 352	3.86E-05	0.53883	0.92579

The analysis variance on the fixation duration with the factors condition and the co-variate sex produces results such that the time on task and condition and time on task have an interactional effect on the participants (*significant effect, p<0.05).

Blink Frequency

Effect on Condition

Mean and standard deviation of the blink frequency for the different conditions (without music, moderate music, loud music) (Table LIV). The analysis of variance for the blink frequency demonstrates that there is statistical significance on the time on task for blink frequency, however, there is no significance on the condition and condition and time on task (Table LV). Figure 29 shows that there is a gradual increase in the blink frequency (blinks/min^{-1}) from the start of the driving session at 130 bl/min^{-1} to the end of the driving task at 153 bl/min^{-1}. The increase in blink frequency may illustrate the presence of fatigue during the conditions. This may demonstrate the fact that music may not necessarily be an appropriate coping mechanism in the alleviation of fatigue.

Table LIV: Mean and standard deviation (±) of the blink frequency for the different conditions (n=25).

Without music	Moderate music	Loud music
13.25055153 (±0.299367058)	14.063 (±0.298124)	13.17196 (±0.195953)

Table LV: The repeated analysis of variance with the factors condition without co-variate on the blink frequency during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Condition	3069.405	2, 38	1534.703	0.636959	0.534451
time on task	8487.698	8, 152	1060.962	4.182042	*0.000151
condition*time on task	1666.063	16, 304	104.1289	0.754762	0.736165

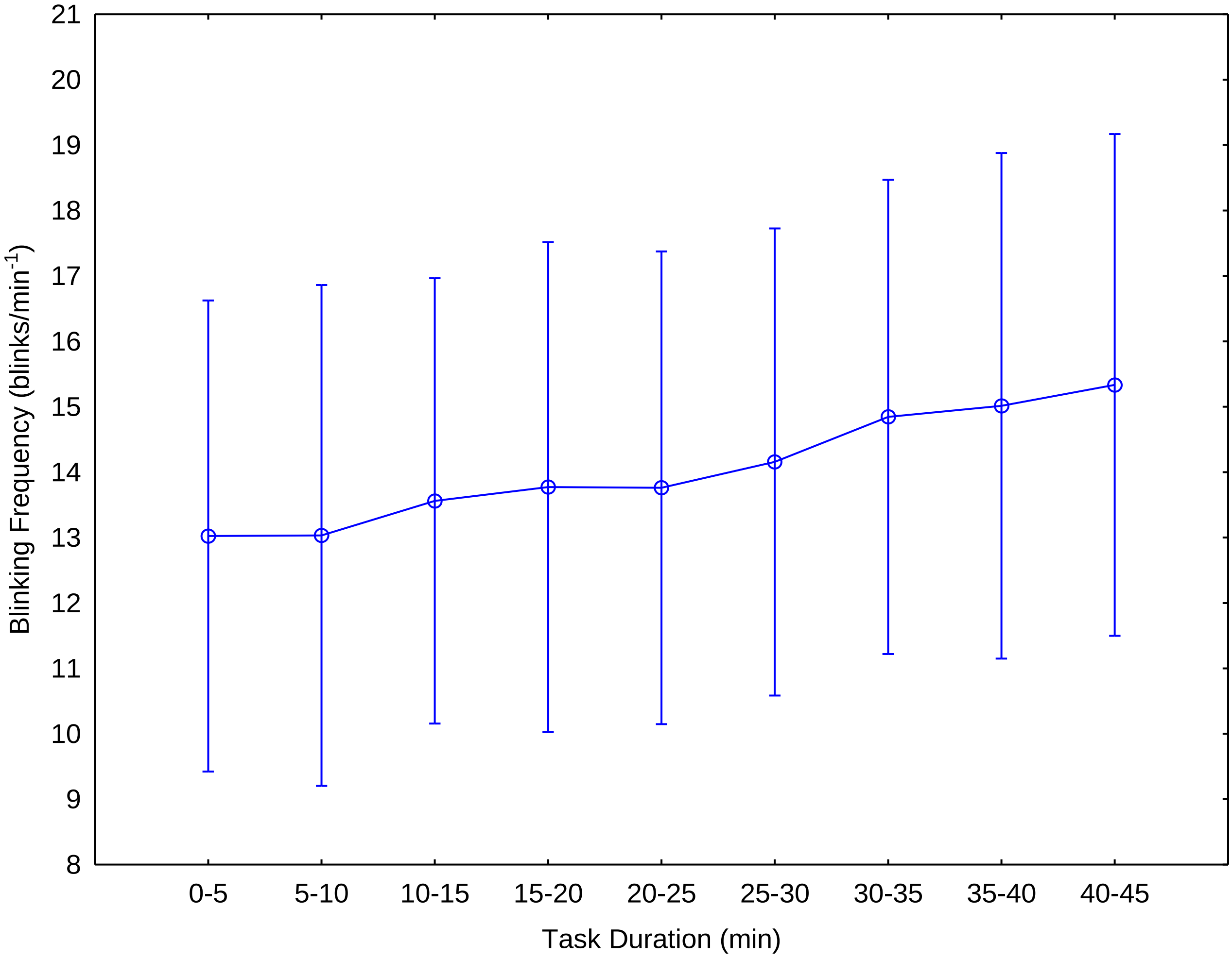

Figure 29: The change in blink frequency (blinks/min^{-1}) over the 45 minute task duration show a steady increase during the driving task for all participants (Error bars denote 95% confidence interval).

Effect on Personality Traits

The repeated analysis conducted on the factors conditions and personality traits illustrate that only the personality extraversion has a significant effect on the blinking frequency (Table LVI).

Table LVI: The repeated analysis of variance on blink frequency with the factors conditions with all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	2621.52	1, 14	2621.52	7.145015	*0.018192
Agreeableness	6.429405	1, 14	6.429405	0.017523	0.89657
Conscientiousness	657.7394	1,14	657.7394	1.792684	0.201935
Neuroticism	997.0233	1, 14	997.0233	2.71741	0.12151
Openness	4.979505	1, 14	4.979505	0.013572	0.908913
Condition	84.88621	2, 28	42.4431	0.614249	0.548178
condition*extraversion	10.24642	2, 28	5.123211	0.074145	0.928719
condition*agreeableness	203.8818	2, 28	101.9409	1.475319	0.245945
condition*Conscientiousness	62.84981	2, 28	31.4249	0.45479	0.639186
condition*neuroticism	3.09436	2, 28	1.54718	0.022391	0.977875
condition*openness	67.47045	2, 28	33.73522	0.488226	0.618842
time on task	48.41196	8, 112	6.051495	1.16266	0.328061
time on task*extraversion	18.86557	8, 112	2.358196	0.453075	0.886277
time on task*agreeableness	10.14023	8, 112	1.267529	0.243527	0.981536
time on task*Conscientiousness	30.75678	8, 112	3.844598	0.738654	0.657191
time on task*neuroticism	5.372993	8, 112	0.671624	0.129038	0.997877
time on task*openness	36.31459	8, 112	4.539324	0.87213	0.542317
condition*time on task	26.8944	16, 224	1.6809	0.387243	0.984505
condition*time on task*extraversion	39.88989	16, 224	2.493118	0.57436	0.901217
condition*time on task*agreeableness	52.10116	16, 224	3.256323	0.750186	0.740264
condition*time on task*Conscientiousness	33.62785	16, 224	2.101741	0.484196	0.953152
condition*time on task*neuroticism	34.64636	16, 224	2.165398	0.498861	0.946276
condition*time on task*openness	32.04716	16, 224	2.002947	0.461436	0.96265

Effect on co-variate age and sex

The repeated analysis of variance for age against blink frequency found no statistical significance (Appendix E).

Table LVII: The repeated effect on blink frequency (blinks/min^{-1}) with the factors condition with co-variate sex during the driving condition (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Sex	3794.769	1, 18	3794.769	11.2649	*0.003515
Condition	85.66696	2, 36	42.83348	0.64816	0.529002
condition*sex	8.018761	2, 36	4.00938	0.06067	0.94123
time on task	331.4259	8, 144	41.42824	8.559884	*1.69E-09
time on task*sex	12.31126	8, 144	1.538908	0.317968	0.958206
condition*time on task	246.7856	16, 288	15.4241	4.005463	*7.02E-07
condition*time on task*sex	73.53	16, 288	4.60	1.1935	0.272082

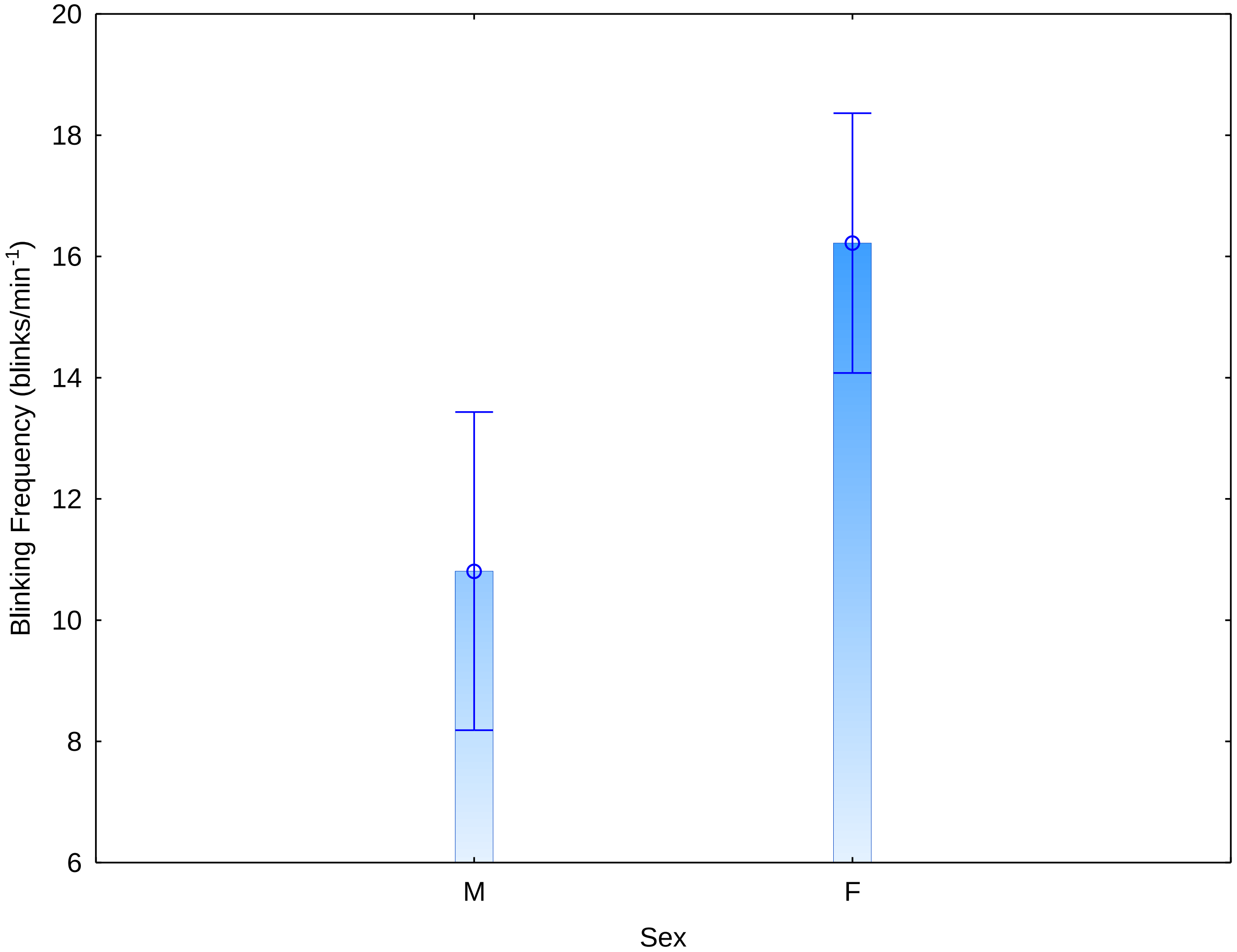

Figure 30: Sex differences on blink frequency (blinks/min^{-1}). Error bars denoting the 95% confidence interval.

Male participants have lower blink frequency at 108 bl/min^{-1} whilst the female participants have higher blink frequency measure at 162 bl/min^{-1}. There is a time on task effect on the on the blinking frequency as well as an interactional effect between condition and time on task (Figure 30).

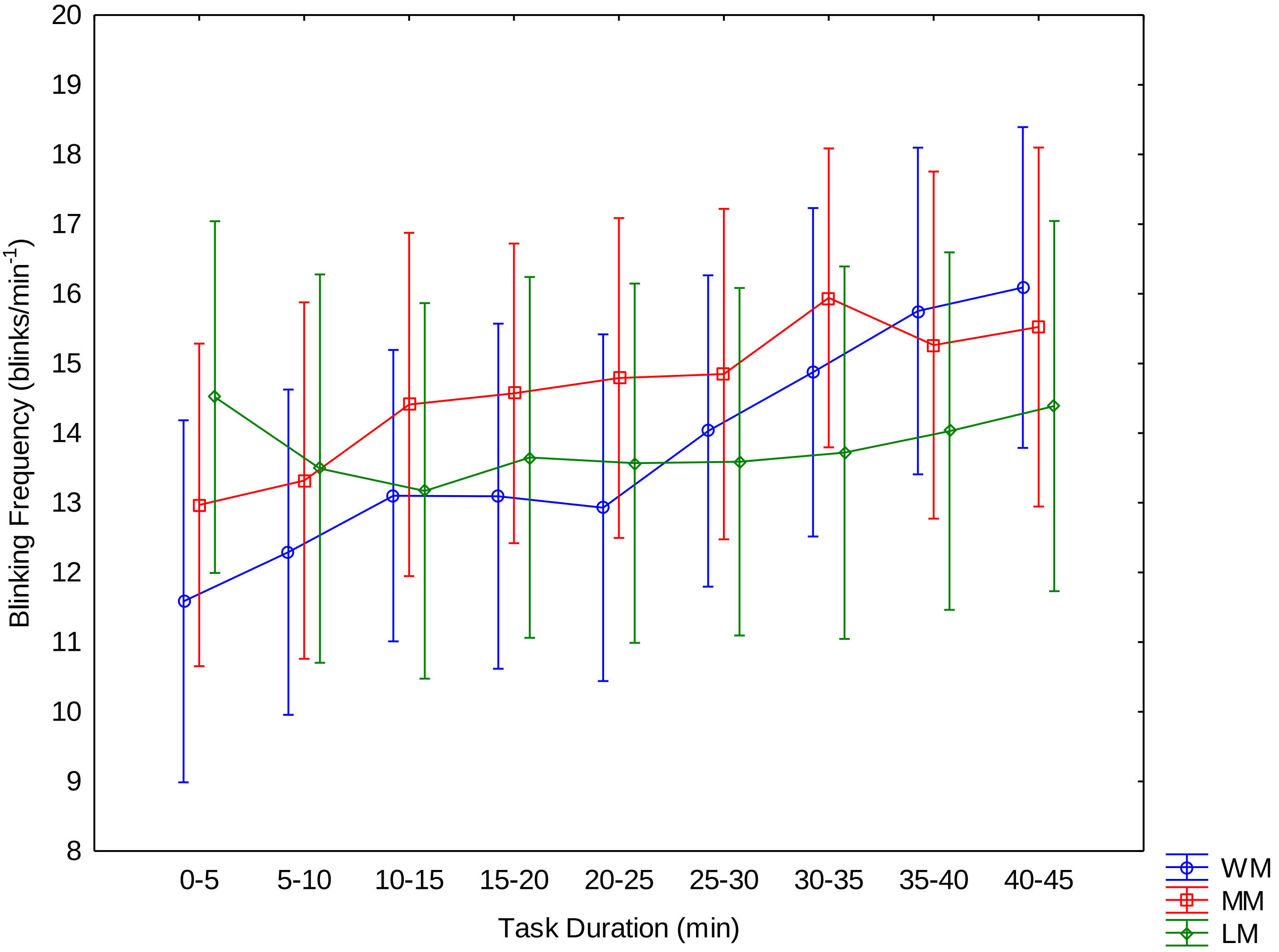

Figure 31: Differences in conditions and time on task on blink frequency (blinks/min^{-1}). Error bars denoting the 95% confidence interval.

Table LVIII: Post Hoc Fischer LSD showing the differences between the conditions for blink frequency (blinks/min^{-1}) (*=significance, p<0.05).

Condition	Without music	Moderate music	Loud music
Without music		0.225301	0.0129
Moderate music	0.2253		0.176339
Loud music	0.0129	0.176339	

Table LIX: Post Hoc Fischer LSD showing the differences between the time of task on the blink frequency (blinks/min^{-1}) (*=significance, p<0.05).

time on task	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45
1		0.105425	0.000511	0.137021	0.001544	0.000006	0.001869	0.027184	0.022554
2	0.105425		0.056401	0.893632	0.112597	0.002483	0.126374	0.548323	0.500316
3	0.000511	0.056401		0.041442	0.744319	0.250272	0.700333	0.188496	0.214321
4	0.137021	0.893632	0.041442		0.085697	0.001616	0.096793	0.463136	0.419469
5	0.001544	0.112597	0.744319	0.085697		0.140722	0.953136	0.321686	0.358899
6	0.000006	0.002483	0.250272	0.001616	0.140722		0.125714	0.014419	0.017555
7	0.001869	0.126374	0.700333	0.096793	0.953136	0.125714		0.351079	0.390382
8	0.027184	0.548323	0.188496	0.463136	0.321686	0.014419	0.351079		0.941118
9	0.022554	0.500316	0.214321	0.419469	0.358899	0.017555	0.390382	0.941118	

Post Hoc Fischer LSD demonstrate statistical differences in blink frequency (blinks/min^{-1}) throughout the 45 minute task duration drive for the nine intervals in 5 minute increments.

Blink duration

Effect on Condition

Once again the mean and standard deviation were calculated for the blink duration (Table LX). The repeated analysis of variance on blink duration with the factors conditions without co-variates indicates that the conditions have no effect on the blink duration. The inferential statistics further disclose that there is a time on task effect on the blink duration (Table LXI). There is an increase in blink duration (ms) show signs of fatigue in participants throughout the 45 minute driving task, starting at 146 ms and at the end of driving task the blink duration had increased to 158 ms (Figure 32).

Table LX: Mean and standard deviation (±) of the blink duration for the different conditions (n=25).

Without music	Moderate music	Loud music
148.6634 (±2.469081)	152.8155 (±2.377504)	147.4669 (±2.213887)

Table LXI: The repeated analysis of variance on the relationship for the conditions on blink duration (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Condition	3069.405	2, 38	1534.703	0.636959	0.534451
time on task	8487.698	8, 152	1060.962	4.182042	*0.000151
condition*time on task	1666.063	16, 304	104.1289	0.754762	0.736165

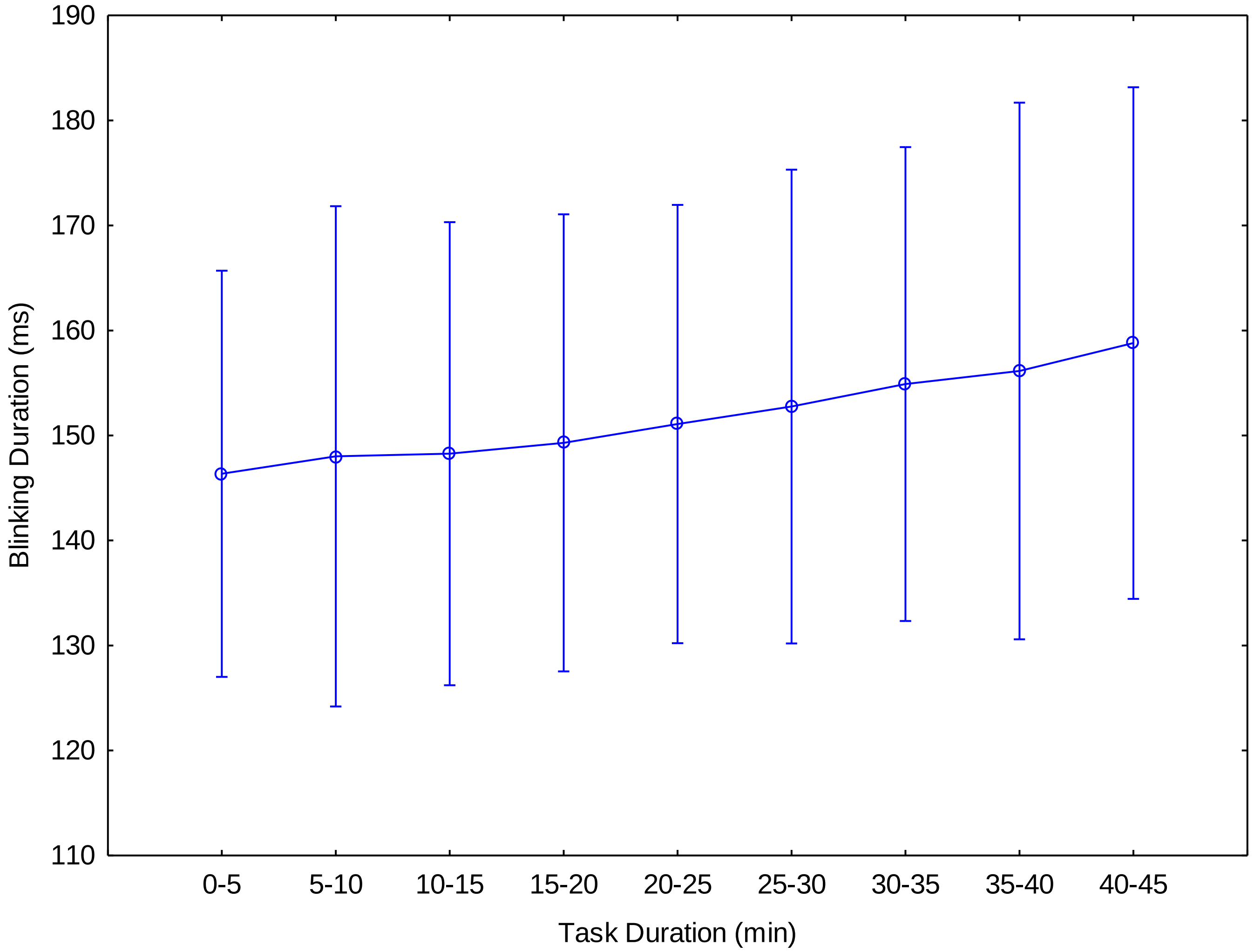

Figure 32: The Blink Duration (ms) showing an increase throughout the 45 minute driving task duration (Error bars denote the 95% confidence interval).

Effect on Personality Traits

The results pertaining to the repeated analysis of variance conducted on the factors condition and all personality traits show that there is an interactional effect on the condition and personality trait agreeableness on the blink duration (Table LXII).

Table LXII: The repeated analysis of variance on the blink duration with the factors conditions and all personality traits during the driving conditions (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	5273.884	1, 14	5273.884	0.230288	0.638721
Agreeableness	2.410892	1, 14	2.410892	0.000105	0.991958
Conscientiousness	337.9289	1, 14	337.9289	0.014756	0.905042
Neuroticism	12923.01	1, 14	12923.01	0.564293	0.464976
Openness	23165.9	1, 14	23165.9	1.011557	0.331598
Condition	1697.61	2, 28	848.8049	0.401815	0.672901
condition*extraversion	8801.762	2, 28	4400.881	2.083329	0.143393
condition*agreeableness	15275.37	2, 28	7637.683	3.615596	*0.040108
condition*Conscientiousness	2365.31	2, 28	1182.655	0.559856	0.577555
condition*neuroticism	5996.347	2, 28	2998.173	1.419303	0.258753
condition*openness	5431.203	2, 28	2715.601	1.285536	0.292323
time on task	1226.319	8, 112	153.2899	0.62534	0.755021
time on task*extraversion	850.1269	8, 112	106.2659	0.433507	0.898721
time on task*agreeableness	2145.507	8, 112	268.1884	1.094064	0.372673
time on task*Conscientiousness	544.4055	8, 112	68.05068	0.27761	0.972081
time on task*neuroticism	2998.974	8, 112	374.8717	1.529274	0.154943
time on task*openness	451.9483	8, 112	56.49354	0.230463	0.984546
condition*time on task	1776.639	16, 224	111.0399	0.876922	0.596537
condition*time on task*extraversion	1850.308	16, 224	115.6442	0.913284	0.554636
condition*time on task*agreeableness	3222.45	16, 224	201.4031	1.590552	0.072591
condition*time on task*Conscientiousness	2141.379	16, 224	133.8362	1.056952	0.398233
condition*time on task*neuroticism	3112.229	16, 224	194.5143	1.536149	0.088659
condition*time on task*openness	2048.323	16, 224	128.0202	1.011021	0.445934

Effect on co-variate age and sex

The repeated analysis of variance conducted for blink duration with factors condition and age effect demonstrates that there was statistically insignificant (see Appendix E).

Table LXIII demonstrate the findings calculated for the repeated analysis of variance on blink duration with the factors conditions and co-variate sex. Sex, shows no statistical significance on blink duration, nor the condition and sex, time on task and sex, condition ad time on task and lastly condition, time on task and sex. There is only statistical significance for time on task on blink duration.

Table LXIII: The repeated analysis of variance blink duration with the factors condition and co-variate sex during the driving duration (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factors	**SS**	**dF**	**MS**	**F**	**p**
Sex	41199.28	1, 18	41199.28	2.321751	0.144953
Condition	3930.332	2, 36	1965.166	0.789274	0.461876
condition*sex	1923.718	2, 36	961.8592	0.386314	0.68234
time on task	8390.563	8, 144	1048.82	4.079956	*0.00021
time on task*sex	1544.016	8, 144	193.002	0.750786	0.646573
condition*time on task	1694.842	16, 288	105.9276	0.768994	0.720357
condition*time on task*sex	2269.094	16, 288	141.8184	1.029547	0.425108

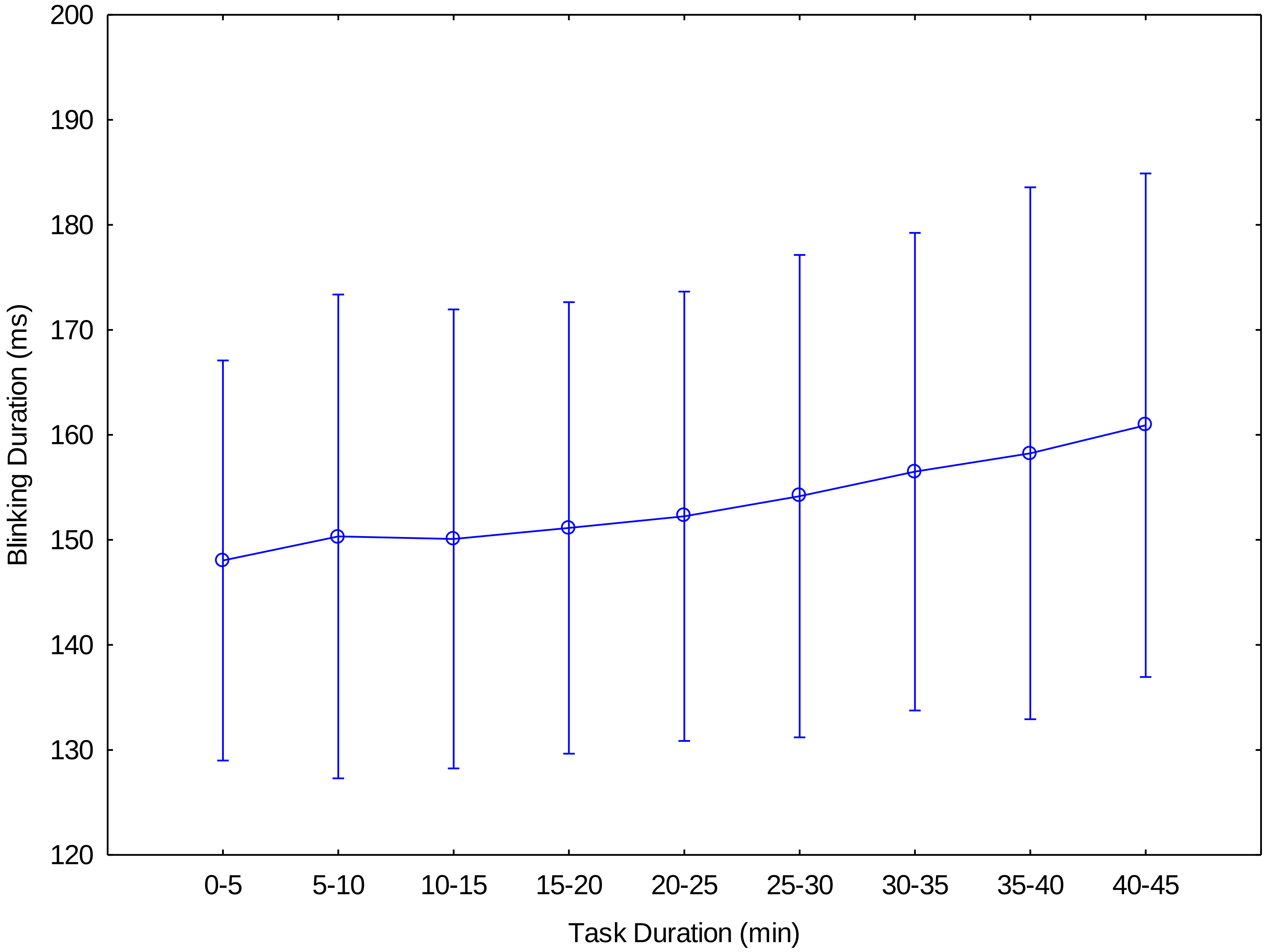

Figure 33: Change in the blink duration showing a gradual increase and changes in blink duration over time.

4.5 SUBJECTIVE PARAMETERS

Multidimensional Driving Style Inventory

Effect of Condition

The descriptive data calculated showed that the average score for the multidimensional driving style inventory of all the 25 participants was a score of 7.32 with standard deviation of 0.6904, which means the participants fell in the careful driving style category, which is deemed as Factor 7 (Taubman-Ben-Ari *et al*., 2012). Furthermore the repeated analysis of variance calculated demonstrated that the Multidimensional Driving Style Inventory is not statistically significant.

Effect of Personality traits

Table LXIV shows the repeated analysis of variance on the personality traits on the multidimensional driving style inventory, of which only the personality trait that indicates significance is that of the conscientiousness trait.

Table LXIV: Repeated analysis of variance for the Multidimensional Driving Style Inventory on personality traits (extraversion, agreeableness, conscientiousness, neuroticism, openness) (*=significant effect, $p<0.05$).

Factor	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	0.000549	1, 19	0.000549	0.001331	0.971282
Agreeableness	0.003963	1, 19	0.003963	0.009597	0.922987
Conscientiousness	2.640294	1, 19	2.640294	6.394645	*0.020459
Neuroticism	0.324011	1, 19	0.324011	0.784736	0.386771
Openness	0.677891	1, 19	0.677891	1.641813	0.215495

Table LXV shows a positive relationship between the conscientiousness trait and the driving style of the participants. That is, the higher the conscientiousness scores of individuals the more careful their driving style (Factor 7), according to the Multidimensional Driving Style Inventory (Section 2.9).

Table LXV: The Spearman rank order correlation table for the personality trait conscientiousness on the multidimensional driving style inventory (*=significant correlation value).

Variable	**MDSI**
Conscientiousness	*0.453017

Effect of co-variate age and sex

NASA-TLX

Effect of Condition

The descriptive statistics of the mean and standard deviation for the adjusted rating score of the NASA-Task Load Index of the different dimensions (mental demand, physical, temporal, performance, effort and frustration).

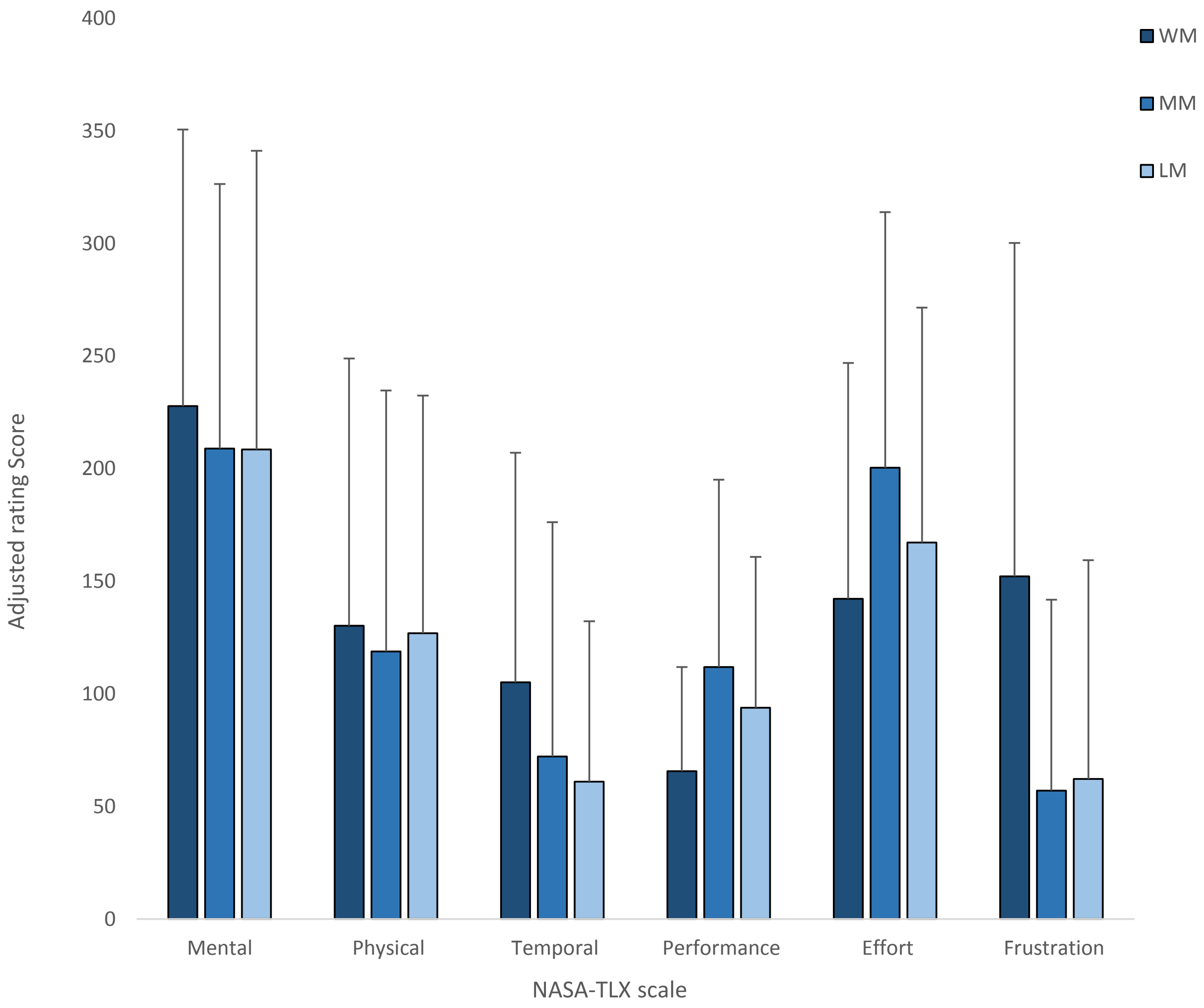

Figure 34: A graph illustrating the mean and standard deviation of the adjusted rating score of the NASA-Task Load Index of the different categories.

The graph illustrates the mean and standard deviation of the adjusted rating score of the six categories (mental demand, physical demand, temporal demand, performance, effort and frustration). For which inferential statistics calculated on the effect of condition on the NASA-Task Load Index show that there is no effect of the condition on the NASA-Toad Load Index scale (Appendix E).

Effect of Personality Traits

Table LXVI: Repeated analysis of variance calculated on NASA-TLX with factor condition and all personality traits during the driving condition for the weighted score (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factor	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	170949	1, 19	170949	2.824772	0.109186
Agreeableness	885616.5	1, 19	885616.5	14.63398	*0.001142
Conscientiousness	811.0077	1, 19	811.0077	0.013401	0.909055
Neuroticism	821244.8	1, 19	821244.8	13.5703	*0.001577
Openness	16512.61	1, 19	16512.61	0.272855	0.60746
Condition	101488.5	2, 38	50744.25	1.689238	0.198232
condition*extraversion	54777.58	2, 38	27388.79	0.911752	0.410429
condition*agreeableness	3706.538	2, 38	1853.269	0.061694	0.940265
condition*Conscientiousness	68906.82	2, 38	34453.41	1.146928	0.32836
condition*neuroticism	25877.36	2, 38	12938.68	0.430719	0.653175
condition*openness	61608.41	2, 38	30804.2	1.025449	0.368346

Table LXVII: Repeated analysis of variance calculated on NASA-TLX with factor condition and all personality traits during the driving condition for the unweighted score (without music, moderate music, loud music) (*=significant effect, p<0.05).

Factor	**SS**	**dF**	**MS**	**F**	**P**
Extraversion	759.7211	1, 19	759.7211	2.824466	0.109204
Agreeableness	3940.76	1, 19	3940.76	14.65083	*0.001136
Conscientiousness	3.739145	1, 19	3.739145	0.013901	0.907382
Neuroticism	3653.184	1, 19	3653.184	13.58169	*0.001571
Openness	73.20826	1, 19	73.20826	0.272171	0.607908
Condition	453.1032	2, 38	226.5516	1.694414	0.197292
condition*extraversion	243.4761	2, 38	121.738	0.910497	0.410921
condition*agreeableness	16.72237	2, 38	8.361186	0.062535	0.939477
condition*Conscientiousness	307.5842	2, 38	153.7921	1.150234	0.327338
condition*neuroticism	115.8809	2, 38	57.94047	0.433345	0.6515
condition*openness	273.3874	2, 38	136.6937	1.022353	0.369429

The Spearman rank order correlations were conducted on the agreeableness and neuroticism personality traits for the NASA-Task Load Index. Table LXVIII, indicates that there is a direct positive relationship between agreeableness personality and the condition without music, but no relationship for the without music and loud music condition.

Table LXVIII: Spearman rank order correlations of the relationship between the personality trait (agreeableness) and the conditions (without music, moderate music, loud music) (*=significant effect of R-value).

Factor	WM1	MM1	LM1
agreeableness	*0.517833	0.387507	0.22667

The spearman rank order correlations were calculated on the neuroticism personality trait for all conditions there was a positive relationship between neuroticism personality type individuals with the three conditions administered (without music, moderate music, loud music). That is the individuals who score high in neuroticism trait on the personality scale are affected by the three conditions (without music, moderate music, loud music).

Table LXIX: Spearman rank order correlations of the relationship between the personality trait (neuroticism) and the conditions (without music, moderate music, loud music) (*=significant effect of R-value).

Factor	WM1	MM1	LM1
Neuroticism	*0.422767	*0.405171	*0.493353

Effect of co-variate age and sex

The repeated analysis of variance conducted on the effect of co-variate age and sex shows that there is no statistical significance on the age and sex on the NASA-Task Load Index scale (see Appendix E).

Perceived control

Effect of condition

The descriptive statistics of the mean and standard deviation for the perceived control were conducted the error bars are very high illustrating that the participant's perception on perceived control vary vastly. However, the repeated analysis of variance conducted for perceived control on the condition without co-variates reveals that the condition on perceived control does not change the ratings of the perceived control. However, the degree of the personality trait agreeableness changes their perceived control regardless of the conditions (without music, moderate music, loud music) administered.

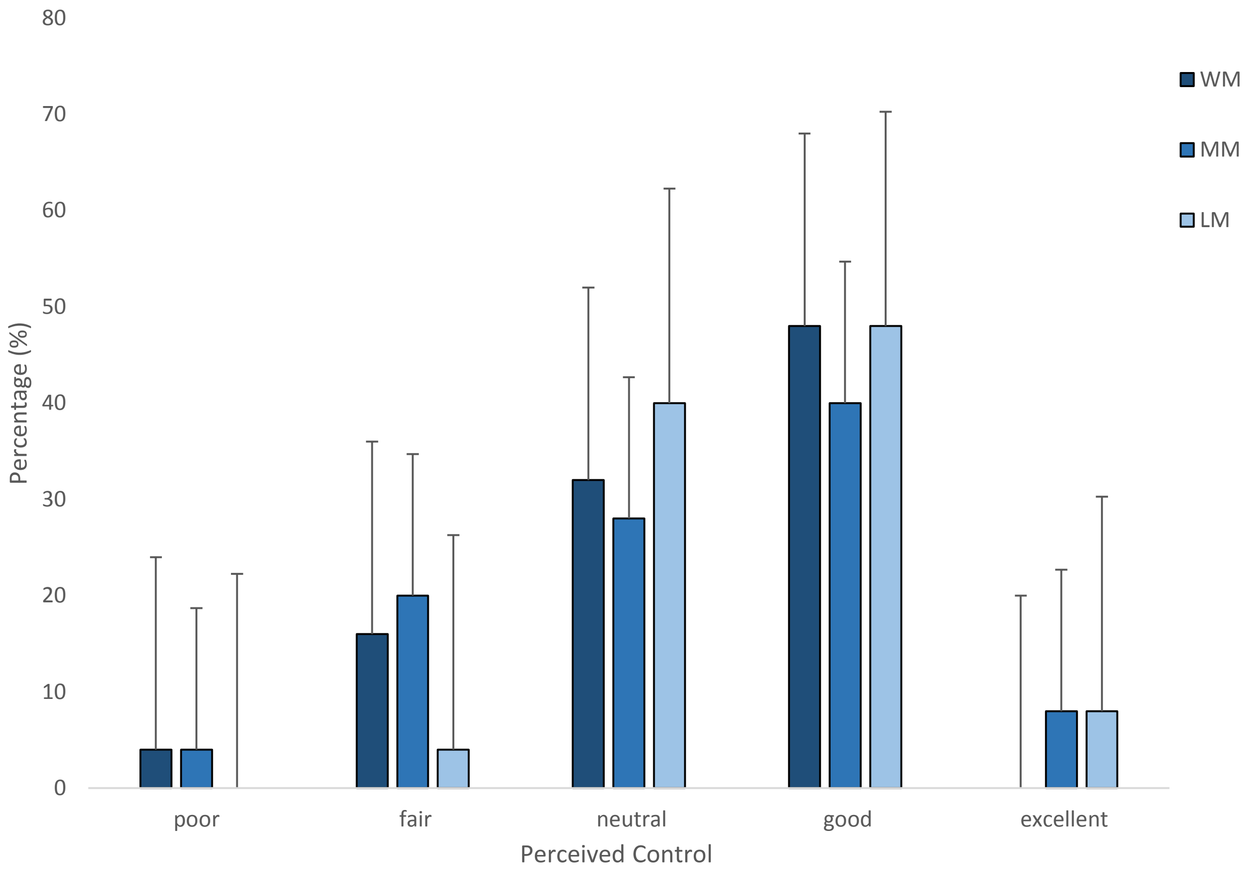

Figure 35: The total average scores and standard deviation for the administered perceived control during the different conditions (without music, moderate music, and loud music).

Effect of Personality Traits

Table LXX: Repeated analysis of variance for perceived control on the personality traits (Extraversion, agreeableness, conscientiousness, neuroticism, openness) with factors condition and without co-variates (*=significant effect, p<0.05).

Factor	**SS**	**DF**	**MS**	**F**	**P**
Extraversion	1.710431	1, 19	1.710431	1.744135	0.202303
Agreeableness	7.707651	1, 19	7.707651	7.859533	*0.011337
Conscientiousness	0.374889	1, 19	0.374889	0.382276	0.543729
Neuroticism	2.042935	1, 19	2.042935	2.083192	0.165214
Openness	0.448389	1, 19	0.448389	0.457225	0.507072
Condition	1.799574	2, 38	0.899787	1.460486	0.244859
condition*extraversion	1.249166	2, 38	0.624583	1.01379	0.372444
condition*agreeableness	0.952163	2, 38	0.476082	0.77275	0.468861
condition*Conscientiousness	1.060717	2, 38	0.530358	0.860849	0.430884
condition*neuroticism	0.60295	2, 38	0.301475	0.489338	0.616842
condition*openness	0.369519	2, 38	0.18476	0.299892	0.742636

The Table LXXI shows the correlations between the personality trait agreeableness and the conditions. Table LXXI shows that there is no relationship between agreeableness and the without music condition, nor is there a relationship between the agreeableness trait and loud music condition. However, there is a negative relationship or correlation between the agreeableness and moderate music. Higher agreeableness score individuals tend to respond negatively towards the moderate music condition.

Table LXXI: Correlations of the relationship between the personality trait (agreeableness) and the conditions (without music, moderate music, loud music) (*=significant effect of R-value).

Variable	Without music	Moderate music	Loud music
Agreeableness	-0.20457	*-0.40247	-0.25185

Effect of co-variate age and sex

The repeated analysis of variance calculated on the condition with the factors co-variate age and sex produced no statistical significant effect on perceived control (Appendix E).

4.6 SUMMARY

In most instances the conditions administered (without music, moderate music, loud music) have no statistical significance on the variable measured other than the pupil diameter of the oculomotor parameters. The time on task had the greatest effect on the objective measures however, not for the subjective measures (Table V). This indicates that the longer one is completing a task, the more likely psychophysiological variables will be affected.

The dominant personality traits to indicate significance for psychophysiological and subjective measures involve the traits (Extraversion, agreeableness, neuroticism) with an account conscientiousness trait showing significance for the subjective measures of the Multidimensional Driving Style Inventory (MDSI), however, this effect was not found for the other subjective measures (NASA-Task Load Index and perceived control), only the Spearman rank order correlations reveal a relationship between certain traits (agreeableness, and neuroticism) and the NASA-Task Load Index in relation to the conditions administered (without music, moderate music, loud music).

The interactional effect between condition and traits show difference of the personality affects for each variable, predominately for the performance and physiological parameters. However, this effect was not found for oculomotor and subjective parameters.

Statistical significance for the interactional effect of the condition and time on task were found for performance and oculomotor parameters, but not for the physiological and subjective parameters. The statistical evaluation of the interactional effect of the time on task and traits illustrate differences of the effect of personality traits; mainly on performance measures, a few for physiological measure, but nothing for the oculomotor and subjective parameters. The condition, time on task and trait display effect for performance measure, some for physiological measures and only for the pupil diameter in the oculomotor parameters but nothing else for the rest of the parameters. Age is only significant for two variables within the physiology parameter, but no significance in all other measures. Time on task and age, condition, time on task and age, time on task and sex and condition and time on task and sex reveal significance only for performance parameters. There is no effect of the condition and sex for all parameters. In conclusion, pattern shows that the subjective measures do not necessarily reveal the same trend as that of the objective findings.

CHAPTER V

5. DISCUSSION

The study looked to assess how different personality traits are likely to respond to different music intensities and the impact this may have on the driving performance. Psychophysiological and subjective indicators were measured in order to deduce an associative or dissociative pattern with the proposed hypotheses. A number of studies have reported that music is positively associated with alleviating symptoms of fatigue during long distance drives (Brodsky, 2001). However, in the same breath there are inconclusive findings associated with regards to this notion (Ünal *et al*., 2012). This chapter's primary objective therefore is to link the initial hypotheses proposed and theory documented in chapter 2 and the outcomes of the experimental procedures of this study in chapter 4 it also aims to give an overview and comprehensive understanding of the concepts reviewed in Chapter 2. This chapter (5) discusses the responses to hypotheses of the parameters measured and outlines the interactions of the conditions, personality traits and co-variates (age and sex) as stipulated discussing mainly the significant results and the possible reasons for the outcomes of the results obtained in chapter 4.

5.1 RESPONSES TO HYPOTHESIS

1. *Effect of Condition*

In general the null hypotheses exemplify insignificant differences between the driving performance, psychophysiological measures, and subjective measures, whilst the alternative hypothesis proposes differences between driving performance, psychophysiological measures and subjective measures. Therefore, the alternative hypothesis is only partially supported because one variable- that of the oculomotor measures- demonstrate a condition effect on pupil diameter.

2. *Effect of Personality*

The null hypothesis states that there will be no effect on driving performance, psychophysiological measures, and subjective measures. The alternative hypothesis states that there will be an effect on the driving performance, psychophysiological measures and subjective measures, for which the alternative hypothesis in the instances is partially accepted because differences in personality traits effects are shown for psychophysiological parameters and subjective measures, but not in driving performance parameters.

3. *Interactional effect between the condition and personality*

The null hypothesis states that there will be no interactional effect between the driving performance, psychophysiological and subjective measures, but the alternative hypothesis states that there will be an international effect on the driving performance, psychophysiological and subjective measures. Based on the results obtained the alternative hypothesis is partially accepted as there is interactional effects in the performance, in some of the psychophysiological parameters, but not is the subjective measures.

In summary it can be said that different parameters respond differently with regards to personality and music during driving. The following paragraphs aim to discuss and interpret these in the light of other research.

5.2 DRIVING PERFORMANCE PARAMETERS

Initially, the study proposed that the different intensities of the music conditions administered would have a substantial difference to the responses in driving performance, due to the literature that suggests that the auditory modality may have an influence on attention processing ability, cognitive capability and/or information processing aptitude, thus impeding driving ability, however that was not the case in this study (Lansdown, 2012; Mishra *et al*. 2013). The results of this study display that there were no condition effects between the tracking deviation (m) and reaction time (s). Therefore, this meant that the conditions (without music, moderate music, loud music) have no effect on the performance of the participant's driving neither negatively nor positively. The intensity of music played during the driving task seemed not to play a role in influencing the performance of the participants.

Primarily the study did not explicitly propose a time on task effect on the driving performance, the results however, showed that the time on task would have a negative impact on the driving performance, such that there would be a decline in driving performance. The time on task affects the capacity for participants to perform due to the fact a "decline in performance is often seen as a characteristic of fatigue with a continuous workload, most commonly associated with a slowing of sensorimotor performance" (De Gray Birch, 2012, p. 120). The decline in performance particularly using the Human Kinetics and Ergonomics simulator is observed and seen when there is a gradual increase in tracking deviation over time performance which illustrates the poor performance of the participants over time. This finding is in agreement with the results found and observed by (De Gray Birch, 2012; Louw, 2013). The study does not observe fatigue, but it does observe the component of it as literature has stipulated that participants try to alleviate fatigue symptoms by listening to music while driving (Berry *et al*., 2013; Wang and Pei, 2014).

The findings on personality traits for all variables however, demonstrate intricacy. Neither of the personality traits (extraversion, agreeableness, conscientiousness, neuroticism, and openness) on their own reveal statistical significance with regards to the tracking deviation (m) and reaction time (s). Thus, the personality traits do not differ in their driving ability, yet for the condition and personality trait interactional effect it shows a statistical significance for neuroticism participants for tracking deviation (m). Conscientiousness, neuroticism and openness demonstrate significances for reaction time. As mentioned in Chapter 2 it has been found that extraverts are more likely to commit road violations and incur more accidents as opposed to introverts, however in this study extraverts illustrate no significance regarding the two performance measures for the tracking deviation (m) and reaction time (s). The studies state that agreeableness participants aren't likely to be associated with riskier driving patterns or crash involvement, and so according to this study agreeableness participants do not reveal significant results pertaining to tracking deviation and reaction time, illustrating that there aren't likely to demonstrate poor driving habits (Rundmo, 2003). It is interesting to note that conscientiousness, neuroticism and openness individuals demonstrate significance results because most studies deduce that conscientious and openness individuals wouldn't demonstrate signs of reduced driving ability or driving anger, and yet these participants in this study have been documented to illustrate statistical significance pertaining to a change in driving performance. The reason for this finding might be due to the fact the condition and the traits together as variables combined reveal significance and perhaps it is an issue of the sample size. Most literature however, reveal that it is probable for neuroticism participants to exhibit reduced driving performance (Rundmo, 2003).

Similarly the condition and time on task effect on tracking deviation and reaction time are both statistically significant. This then means that the condition and the time spent on the task together will elicit differences in the driving patterns of the participants. For example, the reaction time as documented in (Table X) and (Figure 14) demonstrate obvious differences between conditions, such that the participants' reaction time decreased with the condition. The without music showed a reaction time score of 0.396782 (s) and a large variation among participants, and the reaction time during the moderate music condition was found to be 0.303914 s also with a huge variance, but not as large as that of the without music condition, and the least or shortest reaction time is that of the loud music at 0.078879 (s) and the variance between participants is relatively small. This finding demonstrates that there is a preference for participants to listen to loud music while driving. The without music condition was mundane for participants and they experienced more fatigue symptoms than the other two conditions. The preference to listen to loud music while driving may be as a result that the sample size was of young adults who may have a propensity to listen to loud music while driving (Schwartz and Fouts, 2003). This implies that loud music does not interrupt the attention and concentration ability of the participants. In addition, the different personality traits were not equally distributed, thus it is easier to find significant effects for traits where the sample is larger and the variance is smaller.

The findings for the time on task and personality trait disclose that there is a statistical significance on the extraverts and neuroticism participants as well as the conscientiousness, neuroticism and openness for tracking deviation and reaction time respectively. Extraverts and neuroticism display changes in tracking deviation, as both these personality types are probable with negative driving performance results. The time on task may affect these personality types based on the reasoning that, as reviewed in the literature; extraverts' personalities struggle to handle monotonous driving situations and are in need of external or internal stimulation, and neuroticism, which are deemed as having a low score on emotional stability and thus may be associated with being less calm, experiencing more anxiety, worry and poor coping ability during the driving task (Trimpop and Kirkcaldy, 1997; Begg and Langley, 2001; Rundmo, 2003; Schwebel *et al.*, 2007; Dahlen *et al*., 2012; Le Bas *et al*., 2015). It is complex to explain why it could be that the conscientiousness, and openness participants show an effect only for reaction time, but not the tracking deviation. However, the predominant reasoning is attributed to the sample size and variance. The condition, time on task and traits also follow the same trend like that of the time on task and personality trait.

With regards to the age and the condition and age, these reveal no significance which is not unexpected seeing that the population sample and age differences of the sample do not vary vastly. The average age of this sample size was 20.7 years for females and 23 years for males. The time on task and age; and the condition, time on task and age effect display significance for the tracking deviation, this may be due to the fact that the population sample is considerably young and may exhibit impatience in completing the task for which many of the participants informally mentioned the distress they experienced post the testing session. There is a time on task and sex effect on the reaction time, illustrating that the different sexes respond differently with the time on task variable. It is uncertain however to what extent males perform differently from females. This again may be attributed to the sample size. The interactional effect of the condition, time on task and sex has an effect on both the tracking deviation (m) and reaction time (s). That means all the variables combined interact together and elicit the effect on the variable tracking deviation (m) and reaction time (s) and therefore, when one is either listening to music or not and drives for a certain period of time the tracking deviation and reaction time is affected, irrespective of the sex. What is obvious is that time on task or task-induced fatigue occurs and that different conditions of music do not necessarily counteract this phenomenon of induced fatigue, which nullifies the notion that music may alleviate fatigue symptoms when music is listened to throughout the administered task (De Gray Birch, 2012).

In the study conducted by De Gray Birch (2012), tracking deviation (mean deviation) improved during the music stimulus but returned to the pre-music level in the five minute period following cessation of the stimulus. The study also looked at a measure known as the steering alteration frequency, as this was shown to increase during the music and remained at an elevated level thereafter. De Gray Birch (2012) mentions that the increase in steering alteration frequency may be due to the fact that after the stimulus was administered the participants remained more aware of their performance and made a more concentrated effort to perform well. It is also possible that motivation of the subjects increased during the music interval, as they were aware that the task was near completion when the music was introduced. The physiological responses may give an understanding of the notion explained here, detailing the state of the being that is directly or indirectly correlated to the performance.

5.3 CARDIOVASCULAR RESPONSES

Physiological measures in the form of heart rate frequency and heart rate variability measures for this study set out to identify and deduce how the participants were likely to respond to a music stimulus at different intensities during the driving task. The initial assumption was that the different music conditions would divulge indisputable condition effects for the heart rate frequency (bit.min^{-1}) and heart rate variability measures. However, neither heart rate frequency nor heart rate variability measures show an effect on condition entirely (Table V). Moreover, because of the different music conditions Heart rate frequency (bt.min^{-1}) was expected to increase with the intensities which may be indicative of the stress level or the arousal state of the participants due to the music listened to by participants, but the findings show that there was a significant decrease in heart rate frequency throughout the 45 minute driving task from 72 bt.min^{-1} to 70 bt.min^{-1} (Table LXXII) (Figure 15). The decrease in heart rate frequency corresponds with the work conducted by Louw (2013) and De Gray Birch (2012). Instead of administering a music stimulus throughout the driving task as this study has done, De Gray Birch (2012) administered a music stimulus nearing the end of the driving task in order to observe whether participants would be able to counteract the down-regulation in driving performance and the physiological arrears over time. De Gray Birch (2012) asserted that if the music stimulus could improve performance and counteract the physiological debts incurred over time, then effect could be maintained following termination of the music stimulus; therefore the time-on-task effect could be considered more of a down-regulation rather than classifying it as a fatigue response. De Gray Birch (2012) also mentioned that if, the effect was temporary and performance and physiological measures returned to the state prior to implementation of the music, then the state induced could be considered as fatigue.

What is of interest is the fact that De Gray Birch (2012, p. 125) found that all the cardiovascular parameters returned to their “previous level following the music stimulus, favouring the fatigue concept rather than down-regulation.” This study started at a high level, but eventually decreased and remained at a lower state; if the driving task were longer then perhaps heart rate frequency would have decreased even further. De Gray Birch (2012) state the decrease in the heart rate frequency suggested that the music administered might have had a relaxing effect on the participants rather than stimulating them up. Given these findings, music listened to either at the beginning of a driving task and/or at an interim, might have a temporary effect in alleviating fatigue, stimulating attention and/or motivation to continue with the drive thereby contradicting the assumption that music might not have a positive result on driving performance or lighten the symptoms of fatigue or retaining attention strengthening the belief that music eases the monotony associated with driving (Ünal *et al*., 2012). Heart rate frequency has a significant effect on time on task and the time on task and trait (neuroticism). Perhaps, neuroticism participants showing the effect for heart rate frequency may further demonstrate the notion of this personality trait, such that their characteristics resemble having high levels of anxiety, as anxious drivers tend to be more fearful and nervous. Regardless of the driving test having been administered in a laboratory setting the neuroticism participants may have been anxious and nervous in completing the testing session.

Table LXXII: A synopsis of the physiological responses, explaining the possible cause and reaction as a result of the changes over time. The arrows in the table denote increases or decrease of probable outcomes.

Cardiovascular Parameters	**Effect (time on task)**	**Response/probable outcome**
Heart rate frequency	Decrease	↓ arousal ↓ workload
Heart rate variability:		
- rMSSD	Increase	↓ arousal ↓ workload
- SDNN	Increase	↓ arousal ↓ workload
- PNN30	Decrease/Increase/decrease	↑ arousal ↓ arousal ↑ arousal
- PNN50	Decrease/Increase/decrease	↑ arousal ↓ arousal ↑ arousal
- HF power	-	-
- HF centre frequency	Decrease	↓ arousal and workload
- LF power	-	-
- LF centre frequency	Decrease	↓ arousal and workload
- LF relative to (LF+HF)	Increase	↑ arousal and alertness
Oculomotor parameters		
- Pupil diameter	Increase	↑ arousal
- Fixation Duration	Decrease	↓ fatigue ↑ arousal
- Blink Frequency	Increase	↓ alertness ↑ fatigue
- Blink Duration	Increase	↓ alertness ↑ fatigue

Time domain analysis of heart rate variability

As heart rate frequency decreases the heart rate variability measures increases and this was true for the time domain analysis rMSSD (ms) and SDNN (ms) (Figure, 16 and 17). The increase in rMSSD (ms) and SDNN (ms) is said to be indicative of the fatigue state of participants and diminished alertness experienced throughout the driving task and this holds true based on the studies conducted by various authors (Patel *et al*., 2011; ChucDuc *et al*.,2013; Louw, 2013). As mentioned in Chapter 2, studies have shown that heart rate variability is necessary in indicating other physiological states of the human like mental effort and diminished effort, heart rate variability changes along with the of task difficulty (Acharya *et al*., 2006; ChuDuc *et al*., 2013; Louw, 2013). Louw (2013) states that the time domain analysis supports the theory of effort-regulation, which proposes that effort may be necessary in overcoming mentally taxing state of the mind where the time on task participants struggled to maintain performance accuracy of the task demands (Matthews and Desmond, 2002; Oron-Gilad and Hancock, 2005; De Gray Birch, 2012). As mentioned by Sunshine (2013) an increase in heart rate variability rMSSD and SDNN shows a withdrawal of effort from the task (Table LXXII).

Furthermore, the data collected corresponded with the information processing theory which deduces that without a certain level of attention or effort one could experience a breakdown in the thought process, decision making, encoding and transformation and dissemination of the information, as the lapse in attention creates the possible driving errors. Listening to music does not particularly require effort and so the attention lapses when one is confronted with a mundane task influences heart rate variability time domain analysis revealed precisely these theories (Lee, 2008; Adrian *et al*., 2011; Vaportzis *et al*., 2013).

The rMSSD (ms) and SDNN (ms) in this study do not follow the same pattern as expected; the rMSSD only shows significance for the time on task effect and the condition and trait (agreeableness). The study shows that the difficulty in distinguishing causal relationship between variables presents difficulty as the traits to do not reveal similar patterns (Rundmo, 2003). Perhaps, the agreeableness trait showing significance in this instance is due to the sample size which consisted predominately of agreeableness participants. There was also an age effect (Table V) on the rMSSD, age effects for which there could be differences in male and female participants. The SDNN show statistical significance for the time on task and the condition and trait (extraverts). Time domain analysis for PNN30 and PNN50 variable follows the same pattern, and has an effect on the time on task and the personality trait (extraverts) and there is a condition and trait effect (agreeableness). The time domain analysis of the PNN30 and PNN50 shows confounding results from the time domain analysis of the rMSSD and SDNN. The PNN50 in (Figure 19) show slight fluctuations and then a steady decrease, this decrease in PNN50 does not follow the same pattern like the rMSSD and SDNN, which means that in some instances effort-regulation and fatigue may have been played a role and participants may have been alert and the arousal levels might have been high, from the beginning of the task to approximately the 15th minute of the driving task, after which the PNN50 shows increases until the 25 minute, which shows the arousal and workload were decreasing at this point indicating that the extraverts and agreeableness were struggling to counteract the symptoms of fatigue. However, the participants recover again and the arousal state increases thereafter. The increase in arousal may potentially suggest that music has a motivating effect on participants to counteract symptoms of down-regulation and fatigue as indicated for extraverts and agreeableness (Table V; Figure 18; Figure 19). These findings of PNN30 and PNN50 might give a true account of the physiological state of participants when listening to music and driving, such that arousal and workload fluctuate and decrease at various times of the driving task (Table LXXII).

Frequency domain analysis of heart rate variability

Unexpected and complex findings were found for the frequency domain analysis for the heart rate variability. Under observation, the HF power and LF power variables failed to display significant effect of any of the variables as it had been established and documented by De Gray Birch (2012). However, Louw (2013) found increases in the HF power on the time on task, suggesting the complexity of findings and further difficulty in accurately interpreting the frequency domain analysis of heart rate variability measure, despite being a popular measuring tool in deducing the physiological state of participants. The HF centre frequency (band) and LF centre frequency (band) show that there is a decrease on the time on task effect contrary to the findings of De Gray Birch (2012) (Figure, 22 and Figure 23). The interpretation of these findings presents difficulty, due to the fact that the measures vary regarding the different variables. We note however that there is a time on task and trait (openness). The variables condition, time on task and traits would have an interactional effect (extraversion, agreeableness and neuroticism). There is also an age effect on the HF centre frequency. LF centre frequency has a significant effect on the time on task, the personality trait (neuroticism) exhibited significance, again this may be due to the fact that neuroticism participants are nervous and anxious, and so the administered music stimulus may have calmed the participants.

The HF centre frequency band is said to depict the functioning of the parasympathetic or vagal tone (Bernston *et al*., 1997). The decrease in the parasympathetic activity or vagal tone has been associated with high task demands, and the vagal tone measures have been found to influence the rate of respiration under increasing memory demand, multi-tasking or increased task demands (Fairclough et al., 2005; Megan Sunshine, 2013). Furthermore, Sunshine (2013) states that the decreased parasympathetic activity typically an indication of individuals in a rest or relaxed state of the autonomic nervous system and, as this study has shown, there was sufficient task demand to elicit heart rate variability responses(Table LXXII).

With regards to the LF centre frequency band, Fairclough et al. (2005 and Sunshine (2013) demonstrate the role of the LF centre frequency band in relation to the sympathetic and parasympathetic activity found to be exhibited by LF centre frequency. The increase activity of LF band is indicative of task difficulty and increased workload and effort (Fairclough *et al*., 2005). Based on the findings of this study, the decrease in LF centre frequency would imply lowered task difficulty as demonstrated in the methodology and this suggests that there is a decrease in workload and/or effort and arousal, inducing fatigue effect responses and a decrease in arousal state (Fairclough *et al*., 2005 and Sunshine, 2013) (Table LXXII).

The LF relative to LF: HF ratio is said to be reflexive of the mental activity, which according to Louw (2013) and Sunshine (2013) this reflects the sympathetic modulation. Therefore, a decrease in LF:HF ratio can indicate parasympathetic and sympathetic activity as the ratio is commonly used to demonstrate the balance between the parasympathetic and sympathetic function (Bernston et al. 1997). Patel *et al*. (2011) say that the decrease in LF: HF ratio is symptomatic of a greater drowsy state, while an increase shows of the greater mental workload and alertness. The study has found an increase in LF: HF ratio thereby implying that participants increased alertness (Figure 24) (Table LXXII).

In a nutshell, the data collected and analysed demonstrate conflicting findings of the heart rate variability: time domain analysis and frequency domain analysis as these components do not follow a definite and specific trend as assumed. In some instances, the participants demonstrate weakened parasympathetic activity and therefore a relaxed state of being, and in other instances the findings illustrate increased arousal and decreased workload, depicting the activity of the sympathetic component. In my opinion however, this is not particularly surprising based on the fact that the human body is influence by multiple factors and individuals throughout the day can show either sympathetic or parasympathetic dominance or both sometimes interchanging. It is however, believed that the participants demonstrated dominance regarding the parasympathetic nervous system activity. Therefore, further research into the interpretation of HRV parameters (time domain and frequency) is needed concerning workload and arousal as different research comes to different conclusions. The oculomotor parameter will explain and aim to infer whether or not a relationship exists between the cardiovascular findings.

5.4 OCULOMOTOR ACTIVITY PARAMETER

The increased sound intensity shows an increased pupil diameter as seen in (Table XLVI) and (Figure 26). The condition effect shows significant difference between conditions after a Post-Hoc analysis was conducted. The Post Hoc analysis revealed that there are significant differences between the without music and loud music, and significant differences between moderate music and loud music, but no differences between the without music condition and moderate music. The pupil diameter was smallest for the without music and it would gradually increase for the moderate music and it is highest for the loud music. The increase in pupil diameter (mm) demonstrates the arousal state of participants- the louder the music the higher the arousal state or alertness and corresponds with the findings of the PNN30 and PNN50 heart rate variability findings as well as the LF relative to the (LF+HF) ratio of the cardiovascular responses. There is a personality effect of the trait agreeableness and there is also a condition, time on task and trait effect again for agreeableness. The findings demonstrate that the agreeableness participants regarding the variable pupil diameter (mm) show significance. The eye speeds failed to show any significance for all variables. Fixation duration and blinking frequency follow the same pattern, such that there is significant effect on the time on task effect and the time on task and the trait (extraversion). Fixation durations decrease significantly and subsequently this means that a decrease in fixation duration shows that there is reduced element of fatigue, reduced drowsiness and an increase in alertness and arousal, which is opposite to what literature has stated that the increase in fixation durations is synonymous to increased fatigue and decreased alertness (Goble, 2013) (Table LXXII). According to Schleicher *et al*. (2008) eye blink frequency and blink duration are popularly use in indicating the alertness and fatigue in individuals. Therefore, “increased blink frequency is symptomatic of the onset of fatigue and a transition from alertness or wakefulness to reduced vigilance and increase drowsiness, whereas increased blink duration is typically seen in the transition to severe sleepiness” (Louw, 2013, p. 133; Lal and Craig, 2001). In addition, to this Schleicher *et al*. (2008) proposes that short fixations are possibly indicative of the reflexive unconscious that assists in behavioural control, while the medium length is revealing more of the cognitive control, and the increases in eye movements represents one scanning the environment in an attempt to maintain wakefulness and reduce boredom. Louw (2013) state that possible reduction in cognitive fixations in favour of shorter, reflexive fixations could then possibly indicate a withdrawal of conscious attention and/or effort monitoring. Both the blink frequency and blink duration increase and therefore these findings correspond with those of Louw (2013) and Schleicher *et al*. (2008) (Table LXXII).

5.5 SUBJECTIVE MEASURES

The subjective measures show that there is no expectation whether subjective measures follows the same trend as objective measures. The subjective measures for the Multidimensional Driving Style Inventory show that there is no conditional effect and a positive correlation relationship between the drivers' personality trait (conscientiousness) and driving style. The Multidimensional Driving Style Inventory illustrates that the drivers in this study fall under careful driving style (Factor 7), and this is true for conscientiousness trait, seeing that their traits are consistent with the literature proposed that conscientious individuals are careful in nature, efficient and responsible Milfont and Sibley (2012) and Mitsopoulous-Rubens *et al*. (2011) show there is no real association with driving performance in this study, seeing that the performance outcome of participants illustrates no significances (Table LXIV). Despite insignificance for condition effects the study hopes to discuss indirect findings. NASA-TLX completed after the task demonstrated mental demand and effort as the highest contributions to the overall workload experienced, followed by the level of frustration induced by the task. The study will discuss indirect findings to highlight those things that may not depict findings shown in direct findings. Mental effort showed the highest adjusted mean score for the without music condition, this might demonstrate that individuals have to put in more attention and effort to alleviate symptoms associated with monotonous task. What is of interest is the fact that effort was the least adjusted score for the without music condition, but highest for the moderate music condition. This may be due to the fact that moderate music is in between no music and loud music, for which some participants mentioned that the moderate music was hardest to overcome as it produced a lullaby like effect further inducing drowsiness and yet others participants mentioned that they preferred listening to music at moderate level, however it is not reflected in the NASA-TLX scores. The preference to moderate music, thus is against the without music and loud music for which can be seen indirectly in the graph (Figure 34). With participants experiencing increased workload during the moderate music condition as opposed to the without music condition or loud music condition.

Participants were most frustrated during the without music condition, and second to that was the loud music but by a small margin from the moderate condition (Figure 34). These indirect results demonstrate yet again the complexity of the outcomes, and music on mental workload and the personality traits. For the personality traits the agreeableness trait and neuroticism reveal a positive relationship for conditions, more specifically agreeableness showing significance for the without music condition, this means that participants who score high in agreeableness tend to respond to without condition and neuroticism showing significance for all conditions. The correlation for neuroticism individuals seems feasible in this context, as neuroticism individuals show more signs resistant to driving performance, and in this instant to music while driving (Rundmo, 2003; Adrian *et al*., 2011; Milfont and Sibley, 2012). The use of the NASA-TLX did not necessarily prove significance that automation of vehicles in this case the simulated, but illustrated that there reduced effort and low arousal, increase fatigue amongst participants. However, some psychophysiological measures indicated that automation of vehicles might reduce mental ability, concentration and performance thereof.

The Perceived control scale indicated that there were no conditional effects or any other effects for other variables except for the personality trait (agreeableness). There was a negative correlation for the agreeableness trait concerning the moderate music. Perceived control also did not show effects for the co-variates of age and sex.

5.6 INTERGRATED DISCUSSION workload

The condition does not necessarily have an effect on the driving performance, majority of the psychophysiological parameters, and subjective measures. However, one measure that of the pupil diameter - reveals condition effects, attributed mainly towards the arousal state of the participants. It is believed that this finding suggests therefore that the conditions (without music, moderate music, loud music) affect the physiological state of individuals. In this context it is not enough, however, to deduce whether physiological changes would affect driving performance simply based on this one variable (pupil diameter). What is certain is that the arousal and/or mental state is observed as the pupil diameter increases with the increase of the music intensity. It is assumed however, that perhaps under different environmental circumstances the physiological state might have impacted on the driving performance, but the unforeseen limitations like the sample size and personality trait distribution might have yielded different results. For personality types like agreeableness they aren't likely to exhibit poor driving patterns, but the neuroticism participants are likely to demonstrate poor driving patterns (Rundmo, 2003). The interaction between parameters is not particularly distinct, because the psychophysiological parameters do not follow the same pattern as the driving performance or subjective measures, however the results illustrate the state of the participants, which in my opinion is far more relevant as it certainly makes participants and future motorists aware that the conditions administered might not impact performance and therefore it is about the nature of the driving task itself and how one responds physiologically that would impact performance. The fact that motorists believe that music may be used as a source to counteract fatigue effects during long-distance driving is not a definite solution, but only a temporary one, which suffice to say - that motorists should always be well rested prior to undertaking of a drive, more especially a long one (Brodsky, 2001). This is based on the results that music may alleviate in the short term monotony, because the physiological state goes back to the normal proposed level (De Gray Birch, 2012). This is also seen throughout the variables with the time on task effect that shows that the nature of the drive or time of the drive would impact far more on the driving performance, because participants experience fatigue symptoms demonstrated in the heart rate frequency and heart rate variability. There are interactional effects predominately for the driving performance such that all variables, conditions, the traits and the nature of the drive or time on task effect all combined impact on the driving performance. This is plausible considering the fact that the complexity of a driving task is often dictated by the motorist's cognitive effort, visual-spatial ability, memory, information processing, rapid reaction, vigilance and physical factors which is also subject to the motorists' skills and the environment, and the nature of the drive (Chen *et al*., 2013). It is certain that the personality traits respond differently and this is mostly observed with the interactional effects. Of all the variables, the uncertainty in deducing which personality traits respond when is attributed greatly to the sample size and the unequal personality distribution. Agreeableness and neuroticism participants illustrate significance for the NASA-TLX whereas the MDSI shows the driving style predominately for conscientious participants who illustrate a careful driving style, and the agreeableness for perceived control. The findings are integrated such that the subjective measures and psychophysiological measures as well as driving performance do not necessarily interact, but the parameters on their own reveal differences. Again the outcomes found may be as a result of the administered procedure and methodology which is further discussed in section 5.7.

5.7 DISCUSSION OF THE PROCEDURE AND METHODOLOGY

The study aimed to establish how different personality traits might respond to the different intensities of music when driving. The study proposed difficulty in the ability to fully explain the possible reasons for outcomes based on the wide spectrum of findings as influenced by the personality trait, which did not normally follow the distributed curve. The hypothesis proposed showed that for each hypothesis the alternative hypothesis was tentatively supported, based on the significance found for the different variables within each parameter. The chapter here therefore discusses the thesis outcomes and therefore the original aim of the study and the proposed methods. It also aimed to discuss the reflections of the study with regards to the sample chosen, the use of equipment, the task and its potential bias that might be reflected in the study's methodological procedure.

5.7.1 THESIS OUTCOMES

5.7.2 Original aims

The original aims of the study answered the questions as proposed in the *Statement of the Problem* in Chapter 1 which were to:

1. provide analysis of driving performance in a simulated driving task from a psychophysiological, personality trait, and subjective measures perspective.
2. assess the interactional effect between the personality traits of participants under driving conditions.
3. provide an in-depth analysis of auditory distractions in driving performance.
4. investigate whether different music intensities affect different personality traits while driving.

Generally the study achieved all the four objectives, a fatigue component was incorporated but was not the main aim of the study, seeing that most motorists listen to music while driving and consider listening to music as a way to alleviate fatigue (Brodsky, 2001). The project wanted to assess whether music while driving facilitates driving ability on different personalities. The study looked towards establishing awareness in drivers about music and whether differences occur for different personality traits. Responding to these questions however did pose difficulty because of the complexity within the findings.

5.7.3 Proposed methods

To test and assess the expectation of different music intensities on the Big-Five personality traits of individuals during a supposed long distance drive, participants were subjected to complete three driving tasks that did not change; while listening to the different music intensities of sound (without music, moderate music, loud music). The study wanted to outline whether music acted as a distractor or accompaniment of driving performance in trying to alleviate fatigue symptoms associated with long distance drives. Hence, a driving simulator was used to test driving performance, and various equipment such as the speakers so that music can be heard. Additionally the Suunto heart rate monitor measuring heart rate frequency and heart rate variability measures, and the Dikablis eye tracker which observed the eye movements of the participants. The once off administered Multidimensional Driving Style Inventory was used solely to determine whether the driving style of individuals correlated with the objective performance findings and of the personality trait. The NASA-TLX looked at disputes pertaining to mental workload and the perceived control assessing how participants perceived their vehicular control and this looked at whether a correlation exists in the objective performance finding with that of the perceived control scale. Performance variables, cardiovascular and oculomotor measures were recorded continuously. The Multidimensional driving style inventory was administered once-off before the actual testing and the NASA-TLX and perceived control were administered after every condition.

5.8 REFLECTIONS

The reflections of this study consider all aspects that pertain to the sample, task, equipment, and potential bias of the study as the interruptions of the findings presented difficulty and therefore all plausible mishaps and limitations of the methodology leading up to the results, discussion and conclusions ought to be acknowledged.

5.8.1 Sample

The same group of individuals took part in the study. Both male and female participants from different ethnicities took part in the research. The participants took part in the study between 09:00-11:30 and other between 14:30-17:00 (the times that correspond with an individual’s natural circadian rhythm). The study controlled various factors in order to optimise these results pertaining to the original aims of the study. Provision was made to consider the variances of the time of day for testing, driving experience, participants' health, the personality type, ethnical background, eye concerns and age. Some of these extraneous factors however, were not met based on the requirements of the study and in other instances unforeseen circumstances like the breakdown of equipment and load shedding issues. Factors like sleep patterns and diet intake were not important for the study and thus delimited altogether. In addition those that were prone to having issues pertaining to issues of sleeping disorders such as epilepsy, narcolepsy, and attention deficit hyperactivity disorder. The study hoped to recruit at least 30 participants or more, and equal numbers of male and female participants, as well as have an equal representation of personality types however, the study only succeeded to recruit 25 participants due to limitations in both time and participant availability. It is believed that most of the participants fell under the agreeableness trait, because the population included young, receptive university students who may have a positive outlook on life and possibly wanted to please the researcher in order to progress further in their academic careers. Also, university students tend to displa more agreeableness in many instances as they are driven and want to accomplish various goals.

A repeated-design was used as it increased statistical power of how participants responded to the studies task "Deception" for this study was not required, but the knowledge of test length and end-point may have influenced the behaviour and response to the study. The researcher gave participants a small token of appreciation for their invaluable participation in the study. However, this incentive may have also influenced the participants' behaviour to change their original response in order to please the researcher, despite the logistics of the study having been explained thoroughly to the participants. A cohort study might have allowed for better comparisons of the different personality traits for the conditions administered and therefore the interpretation of results might have presented less difficultly with the intricacy of findings pertaining to the significance found for different personality traits of the different variables.

5.8.2 Equipment

The most obvious limitations of this study were the sampling, recruitment of participants and the finding a suitable method in order to categorise the personality trait of the participants. Literature illustrate different methods and scales in order to establish personality traits and whilst some definitions are synonymous to each other, it does pose difficulty concerning the choice of scale to use, some studies used the Eysenck Personality Inventory, Big Five inventory scale, NEO-Personality Inventory and in other instances the Myers-Briggs Type Indicator (Costa and McCrae, 1992; Rundmo, 2003; Classen *et al*., 2011; Dahlen *et al*., 2012; Milfont and Sibley, 2012).The online Big-Five inventory scale should have been assessed for its legitimacy in producing the personality types of the participants, as it was used a number of times. Furthermore, the study failed to acknowledge that participants may have more than one dominant personality trait, for instance participants may score 4.3 for conscientiousness and 4.3 on agreeableness. Given the scope of the study and availability of equipment, the study could not have made use of electroencephalograph (EEG) measures and brain activity results that could have made more of a difference with regards to observing mental workload, hypervigilance of the participants when music was administered or not (Larue *et al*., 2011). Furthermore, the use of other information processing tools could have been used. With regards to the equipment the study may also consider looking towards comparing automated and manual driving (real car driving versus simulator). The subjective measure NASA-TLX administered was run post the experiment and for this study this was considered the most favourable method in testing mental work with interruptions during the experiment as interruptions may have altered the objective findings and the behaviour and therefore confounded results (Louw, 2013). Louw (2013) further mentions that a study conducted by Buck-Gengler and Healy (2001) revealed performance improvements after only a brief task interruption after 30 minutes of work, hence any interruption would alter the results. However, according to (Louw (2013) post-task assessments were not favourable either because participants would need to recall subjective ratings of workload back over an extended driving protocol. As seen in this study the subjective measures do not follow the same significant patterns as the objective parameters and so it begs the question whether subjective ratings could have been eliminated in the study. Participants freely expressed how they felt about the experimentation; the researcher would take informal notes on the experience of the participants. Perhaps for the future when it comes to driving behaviour the study could have considered a more comprehensive questionnaire that looked at the driving behaviour of the participants. The study could also have perhaps considered the use of formal qualitative interviews that would be recorded and interpreted for further examination. As participant nineteen mentions that "music helps to alleviate fatigue seeing that it is enjoyable, but it decreases concentration," and therefore she felt as though her performance decreased at moderate music."

Concerning the use of the Human Kinetics and Ergonomics simulator (Zschernack and Tlhoaele, 2013) proposes that the simulator, although essential for assessments of performance responses, its physical build prevented the use and inclusion of other components of a light motor vehicle, such as the use of clutch, gearbox, brake pedal and accelerator pedal (Zschernack and Tlhoaele, 2013), which can fully automating the simulator and thus make it more realistic for the experiment. This is because the Human Kinetics and Ergonomics driving simulator only requires participants to steer the wheel during each of the conditions proposed, which the simulator software does not completely emulate i.e. driving under authentic conditions. In addition to this, the simulator scene lacks naturalistic road features - those that are representative of real- life driving setting such as traffic, the use of traffic signs, visual cues, billboards, pedestrians and environmental scene. The lack of use in the stop-start (braking and accelerating), and changing of gears activities in a vehicle may have reduced the authenticity of the findings of this study. These aspects may be crucial in obtaining results that are closely related to real-life settings. It is expected that using an advanced simulator may not only affect the participant's mental workload, psychophysiological responses and potentially subjective measures, but also perhaps create further issues like simulator sickness (Zschernack and Tlhoaele, 2013).

5.8.3 Task

There might have been the limitation in the task, such that participants might have incurred a learning effect despite them completing the conditions on different days of which the learning effect is reduced but possibly not entirely alleviated. A further limitation relates to the pre/post tasks used to probe resource utilisation. There is evidence to suggest the mere act of switching tasks increases arousal and elevates the level of cerebral actively, which in turn may mask any signs of fatigue (Louw, 2013).

CHAPTER VI

6. CONCLUSION

The study focused on understanding whether differences in personality traits are affected by the different intensities of music. This was investigated using the low fidelity simulator and various subjective measures. The findings show that conditions alone (without music, moderate music at 50-65 dBA, and loud music at 75-85 dBA) do not impact on the driving performance of the participants. However, psychophysiological parameters are affected such that the heart rate frequency increases. Whilst some heart rate variability variables increase and decrease showing a sign of fatigue during the driving task, music induces arousal effects predominately demonstrated in the pupil diameter variable of the oculomotor parameter. There were interactional effects for the continuously assessed parameters, but not for the subjective measures which suggest that subjective measures did not follow the same pattern as the objective parameters. The difficulty in further interpretation of the findings was as a result of the population sample and the uneven personality trait distribution. The practical relevance, limitations and potential biasness could give further insight into the findings of this study where future research on this topic is discussed.

6.1 PRACTICAL RELEVANCE

The research conducted may establish practical implications for traffic safety campaigns in South Africa, as well as influence driving education for citizens. The assessment of the personality traits gives insight into how these traits influence listening to music while driving, and those who might benefit thereof. The study reveals that listening to music while driving does not necessarily have a positive or negative effect on driving performance, it does however show the effect on the psychophysiological measures. Furthermore it shows that music may not alleviate fatigue symptoms. What is necessary for driving campaigns is to alert motorists on the fatigue elements and to denounce the notion that listening to music while driving may help alleviate fatigue symptoms. It needs to be emphasised that listening to music while driving is a temporary coping mechanism, but it should not be used a permanent solution to overcome fatigue etc. The drivers always need to be reminded of the implications pertaining to “trivial” behaviours in the car small that seem irrelevant but may have dire consequences.

6.2 LIMITATIONS, POTENTIAL BIAS AND RECOMMENDATIONS

The study concedes that there were limitations and potential bias while conducting this research, which might have induced negative results or non-significance, because of the methodological procedures and implementation thereof. With regards to the sample, the study recruited university students, and these students, who were over-represented and therefore the findings cannot make inferences on a wider population as well as older motorists in general. Furthermore, regarding the sample, participants may not react or behave in the way that they would normally behave under normal driving circumstances because of the desire to "please" the researcher thus the study proposes that perhaps the researcher should have set up the equipment in such a way that the participants were not in full view of the researcher, as this may have reduced any form of intimidation caused by the presence of the researcher in the laboratory room for they ought to think no-one is watching, this might have authenticated realist behaviours of participants under the anticipated simulated conditions.

As stipulated previously the researcher took informal notes regarding the perception of the driver of which this could have been a formal part of the study. A qualitative questionnaire or survey could have brought further insight into the opinions of the participants. For example, some mentioned the difficulty in driving with both loud music and moderate music. A study of this magnitude would need to undergo a longitudinal study methods approach for a certain period to time documenting the risk perception, attitude towards traffic and traffic safety, attitudes to music and intensities of music while driving, and risk-taking behaviour as done in the study by Rundmo (2003). What Rundmo (2003) found was that both risk perception and attitude towards traffic safety were correlated with risk-taking in traffic. He also found that adolescents who had a positive attitude towards traffic safety were less likely to exhibit risky driving behaviours. So, how participants perceive music could be vital in interpreting what motorists actually feel and know i.e. whether music is a distraction or not and surveys could be conducted in for different age groups.

In line with subjective tool assessments that which may assess mental workload and cognitive ability the study could have used other cognitive test batteries like those included in the work of Adrian *et al*. (2011) where we find tests that looked at executive functioning assessment which include inhibition, shifting and updating, these are perhaps useful when considering the aspect of music, memory visuo-constructional abilities and speeding information processing.

In terms of the equipment most studies have shown that fast-paced and potentially loud music is associated with an acceleration of speed (Rundmo, 2003; Kass *et al*., 2010). A potential limitation in the use of the Human Kinetics and Ergonomics could be the fact that the simulator's speed remains constant. Measuring of speed could have been a sure indication of driving behaviours influenced by different music intensities, correlating it with psychophysiological measures as well as associating it with personality types. A further limitation regarding equipment might be the use of the Dikablis eye tracker, even though participants were habituated to the equipment by having the eye tracking on, may have created some discomfort because the head unit hurt some participants at the bridge of their noses as anticipated and this may have interrupted participants' performance. Some participants also complained about the eye camera which was too close to the eye. Even though it was entirely harmless, they were still suspicious, and this may have further reduced performance ability.

6.3 FUTURE WORK

A vast amount of literature has investigated driving performance in behavioural as well as technological *lenses* so as to provide necessary mechanisms and safety margins in alleviating the many road accidents that occur daily (Choi *et al.*, 2013). Hence, researchers investigating driving performance may ascertain the limits and safety margins required for safe driving. Future work can consider expanding the study either as a cohort, using the longitudinal study approach and also consider comparing different areas of South Africa, particularly the big cities (Cape-Town, Durban, Johannesburg, and Port Elizabeth) including an investigating into the differences in driving behaviours and performance. This however, would require a vast team constituting of researchers and other professionals within the various organisations like that of the Road Transport Management Corporation (RTMC), National Mortality Surveillance System (NIMSS) and Statistics South Africa (Stats SA) (Statistics South Africa, 2009).

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APPENDICES

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APPENDIX A1

Participant Recruitment Advert

DEPARTMENT OF HUMAN KINETICS & ERGONOMICS DRIVING SAFETY

RHODES UNIVERSITY, GRAHAMSTOWN

MASTERS RESEARCH

WOULD LIKE YOU TAKE PART IN A DRIVING SAFETY PROJECT?!

BACKGROUND

Driving an automobile is an essential part of everyday living. Driving provides the autonomy of freedom and is meaningful in the industry, logistics and economic growth. However, high traffic volumes as well as distractions of the drivers, mental workload, fatigue, alcohol, cellphone use while driving, behavioral components, attitudes and many more contribute to the disproportionally high road traffic fatalities and injuries in middle and low income countries compared to the world average.

Listening to music is one of the most readily used method to alleviate the monotony associated with driving. The effect of Listening to music may therefore have a positive or negative on the individual, which might influence driving performance.

This research will look at how people with different personality traits respond to driving and concurrently listening to music of different intensities.

YOU CAN TAKE PART IF YOU ARE:

- ✓ Female or Male participant
- ✓ All ethnicities
- ✓ 19-35 years
- ✓ Driving experience 1-5 years
- ✓ Healthy (no hearing deficits, blindness, ADHD, epilepsy, sleeping disorders)
- ✓ Contact lenses acceptable

YOU WILL NEED TO BRING:

- ✓ Driver's License
- ✓ Emergency Contact details
- ✓ Play list of music (15 or more songs) on a USB stick

YOU CANNOT TAKE PART IF YOU:

- ✓ Consume alcohol 24 hours prior your test session
- ✓ Participate in strenuous exercise 24 hours prior test
- ✓ You wear spectacles
- ✓ Wear face-makeup, eyeliner, mascara 48 hours prior testing.

MEASUREMENTS

I will measure:

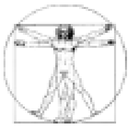
- ✓ Driving Performance (tracking deviation)
- ✓ Eye movements: Pupil diameter, blinking frequency and duration
- ✓ Heart rate frequency and heart rate variability
- ✓ Subjective measures (perceived control scale, NASA-TLX, Multi-dimensional driving style inventory)

BENEFITS OF TAKING PART:

- ✓ Improved understanding of music on concentration
- ✓ Improved understanding on music on driving performance
- ✓ Improved understanding on music on psychophysiological measures
- ✓ Information on music threshold
- ✓ Contribute to important research on driving safety

Risks:

- ✓ Simulator sickness
- ✓ Discomfort from the eye tracker and heart rate monitor
- ✓ Annoyance from music



If you would like to participate please contact me: Keba Tlhoaele

Principal Researcher: Keba Tlhoaele
Phone: 079 218 9167
Email: g09t2889@campus.ru.ac.za

Supervisor: Dr Swantje Zchernack
Phone: 046 603 8472
Email: s.zschernack@ru.ac.za

The study has been approved by the Rhodes University Human Kinetics and Ergonomics Ethical Standards Committee

APPENDIX A2

Screening Questionnaire

Human Kinetics and Ergonomics Department, Grahamstown Eastern Cape, Rhodes University
Kebaabetswe Tlhoaele, g09t2889@campus.ru.ac.za, 079 218 9167

Instruction: Dear Participant. Please provide the researcher with all the correct details and answer all questions truthfully.

*Note the scoring-values in red are not shown to participants.

Please note that you will be excluded from the study if one or more of the following criteria apply:

1. You are younger than 19 or older than 35 years of age
2. You do not have a valid driver's license
3. You have less than 1 year or more than 5 years of driving experience
4. You wear spectacles (contact lenses are acceptable)
5. You have consumed alcohol 24 hours prior to each testing session
6. You have any sleeping disorders
7. Participate in strenuous exercise 24 hour prior to testing
8. You have hearing disability, an ear infection, have suffered hearing loss.
9. You wore eye-liner, mascara, eye-shadow, face makeup, 48 hours prior testing or hours prior the test.
10. You have a history of epilepsy, ADHD and/or similar disorders.
11. If you experience nausea or any other illness during the testing, simulator sickness, you will not be allowed to continue with the study and any data obtained will be disregarded.

Name: ____________ Email address: ______________ Cell number: ____________

Sex: _____________ Age: ___________ Participant code: _____________

Instruction: Dear participant. Please tick in the relevant box.

Driving Experience:

From the time you obtained your driver's licence, how many years driving experience do you have?

1 year (1)	2-3 years (2)	3-5 years (3)

How many long distance trips have you done as an active driver in the past 1-2 years?

Never (1)	Few times (four times in a year) (2)	Often (8 times in a year or more) (3)

Simulator Experience:

Have you had experience with the Human Kinetics and Ergonomics driving simulator?

No, never (1)	Few minutes at a time (2)	More than 1 hour continuously (3)

Music and driving Experience:

Do you listen to music while driving? If yes, how often?

No, never (1)	Few minutes at a time (2)	Continuously throughout a 45 minute drive or more (3)

At what intensity do you listen to music when driving?

Low level music (I can converse with a passenger without difficulty) (1)	Moderately loud music (I may struggle to converse with a passenger) (2)	Loud music (I cannot converse with a passenger at all) (3)

Have you ever been involved in a minor or major accident as a result of listening to music while driving? (Listening to music as a distraction).

Yes (1)	No (0)

APPENDIX B1

Letter of Information

Human Kinetics and Ergonomics Department, Grahamstown Eastern Cape, Rhodes University
Kebaabetswe Tlhoaele, g09t2889@campus.ru.ac.za, 079 218 9167

Dear Participant,

Thank you for your sincere interest as a participant in this study titled "**Do differences in personality traits affect how drivers experience music at different intensities?"**

This letter serves to explain the aims, risks and benefits associated with the study as well as what is required of you in order to take part in the study. Please ensure that you read through the letter carefully including the accompanying consent form. The consent form will be signed at the Human Kinetics and Ergonomics Department during the screening, habituation and introduction session. Your contribution to this study is greatly appreciated.

BACKGROUND, AIM, PURPOSE:

The aim of the study is to ascertain the extent to which different personality traits respond to the effect of listening to different intensities of music while driving, and to measure the driving performance, psychophysiological parameters and subjective measures thereof. Listening to music is one of the most readily used methods of alleviating the monotony, boredom and/or fatigue of a long duration drive rather than conversing with pedestrians (Brodsky, 2001). The automobile has been shown to be the most popular location for listening to music, especially when the driver is driving without company (Brodsky, 2001). The effect of listening to music may therefore have either a positive or negative effect on the individual, depending on the genre of the music played and the sound intensity level of the music, as well as the individual differences with regards to the preference to music genres and sound intensity of the music, which may affect mental effort, attention, concentration and ultimately driving performance in this regard (Brodsky, 2001).

The study looks to investigate whether music positively or negatively affects driving performance of different personality traits, as it has been seen that individual differences, knowledge, attitudes, and so on play a role in how individuals perceive life and how they behave and, in this instance, driving behaviour (Vanlaar and Yannis, 2006). The driving performance measures, psychophysiological and subjective measures are investigated to understand the interactional relationship between your personality trait, the different conditions and the result of the subjective measures.

PROCEDURE:

You will be required to attend four laboratory sessions at the Human Kinetics and Ergonomics Department. One that entails the screening, habituation and introduction to the equipment session, and three of which are the testing sessions, which will occur on three consecutive days.

The screening and, habituation session, as well as the introduction to the equipment will run for approximately 125 minutes and this will include:

a) An oral briefing of the study's aims, procedures and requirements
b) Interested and willing candidates will then sign the consent form, complete the screening questionnaire, which includes: demographic information, questions related to driving experience, simulator experience, listening to music while driving experience and consequences of listening to music while driving, if any. There after you will be required to complete an online Big-Five Inventory scale. The version of the scale highlights the use of the scale, how the scale ought to be completed, as well as the participation. Participation in this instance refers to the fact that the use of the assessment can be used for educational and personal purposes, of which the study takes on the former. In addition to the scale not only uses language, but also tests in the form of visual imagery. The scale tallies and scores your results and thereafter, I will record which personality trait you may fall under. Then you will be required to complete the Multidimensional Driving Style Inventory
c) Introduction to the equipment and familiarisation of the two subjective measure questionnaires (Perceived Control Scale and NASA-TLX)
d) Fitting of the heart rate monitor and eye tracker
e) Driving task training period that will last 3 minutes
f) Debriefing.

The online Big-Five self-report inventory scale is used to obtain the dominant personality type of the participants taking part in the study. The Big-Five is deemed as the most reliable self-report inventory by professionals and thus used in psychological evaluation in patients as well as categorisation of personality traits as constructed by the several authors (Dahlen and White, 2006; Baker and Bichsel, 2006; Besharat *et al*., 2011; Dahlen *et al*., 2012; Park *et al*., 2013). Should you want to continue with the study you will then be required to sign the consent form we will then schedule an appointment and a time that best suits you between 9:00 am-12:00 pm and 2:30-5:00 pm to complete the three conditions.

For the initial screening and habituation session will last no longer than 125 minutes, you are to bring with you your playlist of music, consisting of 15 or more songs of your choice on a USB flash stick. I will then proceed to verbally explain the background, aims and purpose of the study. As pointed above you will then need to complete the screening questionnaire to ensure eligibility of your participation. You will be required to complete an Online Big-Five Inventory scale and lastly you would be required to complete the Multidimensional Driving Style Inventory.

Thereafter, I will introduce you to the equipment (the driving simulator, heart rate monitor, Dikablis eye tracker) and familiarise you to the two subjective questionnaires and procedures. The driving simulator is equipment used to measure driving performance variables such as tracking deviation (Göbel *et al*., 2008). The driving simulator is presented by a curved road with a yellow arrow at the bottom of the screen (Göbel *et al*., 2008). The triangle represents the bonnet of the vehicle. You will need to track the middle white line, with the tip of the yellow triangle as accurately as possible. The speed of the vehicle remains constant throughout the testing sessions (Göbel *et al*., 2008). You will be fitted with the heart rate monitor for which a conductive gel is applied on the heart rate strap used to detect your cardiac responses. The conductive gel will not cause you bodily discomfort or skin reactions. The heart rate monitor will measure heart rate during each of the conditions; from this the heart rate can also measure heart rate variability which forms part of the data in the study. You will then need to take a seat on the low-fidelity simulator and I will proceed to have you wear the Dikablis eye tracker's head unit, which weighs only 69g and will not limit body movement or head movement or cause discomfort during the testing. The Dikablis eye tracker may cause slight irritation to your forehead and the bridge of your nose, due to your unfamiliarity with it, but it will not cause serious harm or injury. The Dikablis software is used to calibrate and collect data of your eye movements and therefore it will be used throughout all three testing conditions. I will habituate you to the eye tracker as the eye tracker requires calibration; therefore this will entail you to listen carefully to my instructions. You will be required to keep your head as still as possible and for you to focus on the projector screen that is in front of you. You will be instructed to do the following:

1. Keep your head as still as possible at all times during calibration.
2. You will need to look straight ahead, at the centre point, which I will show you where the centre point is in relation to the board in front of you.
3. Your pupil needs to be detected first.
4. The pupil will then be isolated on the eye camera video stream.
5. I will then adjust the eye detection parameters on the software, for example adjusting your pupil diameter and ratio so that I achieve the best results when testing commences.
6. Once your pupil has been located and adjusted accordingly, I will go on to calibrating the Dikablis eye tracker, so that the data obtained is reliable.
7. Upon instruction, you will be asked to use your eyes only and look at specific pointers on the projector screen; on the centre of the screen, bottom left corner, top left corner, top right corner and bottom right corner.

Then I will ask you to look at the points mentioned above. Step 7 is repeated again, after which calibration has been completed.

Once calibration has been completed, you will be reminded of the driving task. The yellow triangle of the simulator scene represents the bonnet of the vehicle and you ought to track the white line with the tip of the triangle as accurately as possible. You will be allowed to practice on the driving simulator for three minutes. Thereafter you will be asked to remain calm for a period of 5 minutes so that the baseline readings of your heart beat can be obtained. A debriefing session will occur after the habituation session, of which we will then schedule an appointment to complete the three conditions.

Upon arrival to the Human Kinetics and Ergonomics Department, please note that during the testing session, I will screen you again to see that you have complied with the requirements of the study. This is to ensure validity and reliability of the results gathered. Once again, the study will follow the same procedure as mentioned above such that you will be fitted with the heart rate monitor for which a conductive gel is applied on the heart rate strap used to detect your cardiac responses. The heart rate monitor will measure heart rate during each of the conditions; and once again from this the heart rate can also measure heart rate variability which forms part of the data in the study. You will then need to take a seat on the low-fidelity simulator and I will proceed to have you wear the Dikablis eye tracker's head unit. The same calibration process will occur and you will be given a three minute practice run on the simulator or until you feel ready to commence the test. Again, you will be asked to remain calm for a period of 5 minutes so that the baseline readings of your heart beat can be obtained prior the actual testing. Once this is done, you will need to complete a 45 minute driving protocol for each of the conditions and you will need to complete two subjective measures the NASA-TLX scale and Perceived Control Scale for post reading analysis after each condition.

RISKS AND BENEFITS:

It is unlikely that you will experience any injuries during this study, as the procedures are not considered harmful in any way. However due to the length of the protocol, there is a possibility that you may experience simulator sickness, which is a condition affiliated with one experiencing nausea and dizziness (Roenker, *et al*., 2003; De Gray Birch, 2012). This feeling will however dissipate once you have stopped the driving task, and you will remain seated so that the symptoms of simulator sickness may dissolve. If you feel you are unable to complete the protocol due to this discomfort, you may discontinue from the study without negative consequences.

There is a possibility you might experience annoyance from listening to the music at the different intensities while driving as well as discomfort from the eye tracker and heart rate monitor that will be on you throughout the testing.

In the unlikely event that you may incur an injury during the study as a result of either the equipment or the experimental protocol, the Human Kinetics and Ergonomics Department will be liable for any costs which may ensue and will reimburse the subject to the full amount i.e. the doctors consultation and medication costs etc. If, however, you are in a critical state (unresponsive to a call, showing signs of being unconscious) during the testing, we will seize the testing session all together and I will call the ambulance immediately, of which you will assisted by professional paramedic and they will escort you to the local hospital. The Human Kinetics and Ergonomics Department however, waivers, any legal recourse against the Department, researcher, and University from any and all claims resulting from self-inflicted injuries or negligence on the part of the participant or from injuries or illnesses not directly related to the research study.

You will have no direct benefits from the test, but the results and research conducted may enhance an improved understanding of music on concentration, music on driving performance and an improved understanding on existing research related to driving safety, necessary in alleviating risk and enhancing awareness. If required, feedback will be given to participants later in the year on the results obtained.

ANONYMITY:

Your identity will remain anonymous; you will be assigned a participant code purely for data capturing purposes and I will have the Master's list of codes. These codes will be kept private. For this study, pictures will only be taken with your permission. The pictures taken will be blurred to protect your identity. Moreover, the pictures taken are for illustrative purposes. The data used is only used for purposes of this research study, in conferences, seminars and if the article is published.

REQUIREMENTS:

a) Please eat a light meal prior your testing session (9:00 am-12:00 pm) and between (2:30 pm-5:00 pm), this depends on the time slot you have chosen for the testing.

b) Please bring with you your driver's license.

c) Please bring with you, your play list of 45 minute duration during the screening, habituation and introduction session.

d) Please receive at least 6-8 hours of sleep.

e) Please do not consume alcohol 24 hours prior the testing or any substance likely to hamper your mental and physical ability or reduce your performance.

f) Please do not consume caffeine 24 hours prior your testing session.

g) Please do not participate in strenuous exercise prior the testing as this will exhaust you and you may struggle to complete the scheduled 45 minute drive.

h) Please do not wear eye makeup 48 hours prior testing (eye shadow, eye-liner, mascara) this disrupts detection of the pupil and recordings of the eye movements taken by the Dikablis eye tracker.

i) Please report to the department 10-15 min each testing day prior the testing time.

Please contact the researcher if you are unsure of the aim of the study, risks and benefits, requirements, who will attempt to timeously address any queries. Please also inform the researcher if you are unable to comply with the requirements before testing occurs.

Thank-you for your time and co-operation

Yours sincerely,

Keba Tlhoaele

Principal Researcher: HKE Masters student

g09t2889@campus.ru.ac.za

079 218 9167

Rhodes University

Dr Swantje Zschernack

Supervisor

s.zschernack@ru.ac.za

046 603 8472

Rhodes University

APPENDIX B2

Participant Consent Form

I, ________________________ do hereby consent to participate in the research study entitled "Do differences in personality traits affect how drivers experience music at different intensities?"

The study was verbally explained to me by the researcher and I have read the information letter, and I understand the conditions and procedures that I am expected to comply with. I am also aware of any potential risks and hazards associated with the research, which are highly unlikely and I am still willing to participate. Any queries concerning this study have been answered to my satisfaction. I understand that I will need to complete an Online Big-Five Inventory scale and the information provided therefore is only for educational purposes and will not be used for diagnostic purposes. I understand that I will be given a participant code for purposes of data collection. I also understand that although my anonymity will be protected at all times, the results obtained from this study may be published for statistical and scientific purposes. I understand that pictures can only be taken with my permission and that the pictures can only be used for illustrative purposes.

I am fully eligible to participate in the study and I fit in the participation criteria as listed in the Letter of Information. Moreover, I understand that I will prompt the researcher immediately of any signs and symptoms indicating any distress.

In, agreeing to participate I accept joint responsibility together with the Human Kinetics and Ergonomics Department; in that in the case of an unforeseen incident occurring the Human Kinetics and Ergonomics Department will be liable for consultation and/or medical costs ensuring I have fully recovered. The Department will, however, waiver any legal recourse against the researchers of Rhodes University, from any and all claims resulting from negligence on my part or from injuries not directly related to the research study. I am aware that at any point I may withdraw my consent and participation in the study without negative consequences.

I have read and understood the above information as well as the information provided in the letter accompanying this form.

Participant: …………………… Date: …………………

Researcher: ………………….. Date: …………………

Witness: ……………………… Date: …………………

APPENDIX B3

Ethical Clearance

Human Kinetics and Ergonomics
Application for Ethical Approval

RHODES UNIVERSITY
Where leaders learn

Student Name:	Keba Tlhoaele
Type of Research:	MSc Study
Project Title:	Identifying whether the effect that music has on driving performance is dependent on the different personality traits.
Supervisor:	Dr. Swantje Zschernack
Application received:	13 October 2014

Dear Keba,

Please find the reviewers' comments on the following page. Both reviewers have made some minor suggestions for you to consider.

Approved	Approved, on condition that suggestions have been effected ✓	Request for rework and resubmission	Rejected

Signed

Miriam Mattison.

MC Mattison
Chair: Human Kinetics and Ergonomics Ethics Committee

Confidential
HKE Ethical Committee Review Form

APPENDIX C1

Perceived Control

Instruction: Dear participant please rate your perception of the vehicle control/ driving skills according to the scale provided below. Tick the necessary box.

1.

Perceived control after without music condition while driving:

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

2.

Perceived control after with moderate music while driving 55dBA:

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

3.

Perceived control after with loud music while driving 75dBA:

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

NASA-TLX PARTICIPANT INSTRUCTION

This questionnaire will assess your performance as well as provide an indication to your physical and mental experience while performing the driving task and concurrently listening to music at different intensities.

The first part is the pairwise comparison and we will assess the dominance of a certain dimension or scale over another while performing a certain task. You will be presented with 15 pairs of dimensions/scales for example effort vs mental demand). The dimensions are provided with definition to further enhance your understanding of the word at what it actually means. You would then circle which dimension contributed more to workload after every task. After completing this section, the pattern of your choices will be used to create a weighted combination of ratings from a specific task into a summary workload score. Please consider your choices carefully. There is no known correct pattern. We are interested solely in your subjective opinion.

The second part of this questionnaire, ratings, is useful as here is no effective 'ruler' that can be used to estimate the workload of various activities. You will be required to rate the six dimensions by marking with a cross you perception of the task. The scale is 10 cm wide and are divided into 20 intervals. The ratings are converted to scores that vary from 0 to 100. Therefore every 10 cm is equals to 10. Again, please read through the descriptions of each dimension/scale carefully. Ask the researcher for clarification if you need to.

Your active participation in filling out this questionnaire is essential for accurate results and will be greatly appreciated.

Thank-you for your co-operation

Yours Sincerely,

Keba Tlhoaele

Principal Researcher: HKE Masters student

g09t2889@campus.ru.ac.za

079 218 9167

Rhodes University

Dr Swantje Zshernack

Supervisor

s.zchernack@ru.ac.za

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Rhodes University

APPENDIX C2

NASA-TLX RATING SCALE DEFINITION

(Taken from Hart and Staveland, 1988)

Figure 8: NASA-TLX RATING SCALE DEFINITIONS

Title	Endpoints	Descriptions
MENTAL DEMAND	*Low /High*	How much mental and perceptual activity was required (e.g., thinking, deciding, calculating, remembering, looking, searching, etc.)? Was the task easy or demanding, simple or complex, exacting or forgiving?
PHYSICAL DEMAND	*Low /High*	How much physical activity was required (e.g.. pushing, pulling, turning, controlling, activating, etc.)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
TEMPORAL DEMAND	*Low/ High*	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
PERFORMANCE	*good/poor*	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
EFFORT	*Low/High*	How hard did you have to work (mentally and physically) to accomplish your level of performance?
FRUSTRATION LEVEL*i*	*Low /High*	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

NASA-TLX LOAD INDEX

PAIR COMPARISONS OF DIMENSIONS/ SCALES

CODE:	**TASK:**	**DATE:**

Instruction: In each box, please circle the word/component that best represents the more contributor to the workload you experienced for this particular task.

EFFORT (How hard did you have to work to accomplish this task?) Or PERFORMANCE (How successful do you think you were in accomplishing the task?)	PHYSICAL DEMAND (How much physical activity was required?) Or FRUSTRATION (How discouraged, insecure, or stressed did you feel while performing task?)	MENTAL DEMAND (How much mental activity was required?) Or PHYSICAL DEMAND (How much physical activity was required?)
TEMPORAL DEMAND (How much time pressure did you feel while performing this task?) Or EFFORT (How hard did you have to work to accomplish this task?)	PHYSICAL DEMAND (How much physical activity was required?) Or TEMPORAL DEMAND (How much time pressure did you feel while performing this task?)	FRUSTRATION (How discouraged, insecure, or stressed did you feel while performing task?) Or MENTAL DEMAND (How much mental activity was required?)
PERFORMANCE (How successful do you think you were in accomplishing the task?) Or FRUSTRATION (How discouraged, insecure, or stressed did you feel while performing task?)	TEMPORAL DEMAND (How much time pressure did you feel while performing this task?) Or MENTAL DEMAND (How much mental activity was required?)	PERFORMANCE (How successful do you think you were in accomplishing the task?) Or MENTAL DEMAND (How much mental activity was required?)

PHYSICAL DEMAND (How much physical activity was required?) Or PERFORMANCE (How successful do you think you were in accomplishing the task?)	FRUSTRATION (How discouraged, insecure, or stressed did you feel while performing task?) Or EFFORT (How hard did you have to work to accomplish this task?)	MENTAL DEMAND (How much mental activity was required?) Or EFFORT (How hard did you have to work to accomplish this task?)
TEMPORAL DEMAND (How much time pressure did you feel while performing this task?) Or FRUSTRATION (How discouraged, insecure, or stressed did you feel while performing task?)	PERFORMANCE (How successful do you think you were in accomplishing the task?) Or TEMPORAL DEMAND (How much time pressure did you feel while performing this task?)	EFFORT (How hard did you have to work to accomplish this task?) Or PHYSICAL DEMAND (How much physical activity was required?)

NASA Task Load Index

Hart and Staveland's NASA Task Load Index (TLX) method assesses work load on five 7-point scales. Increments of high, medium and low estimates for each point result in 21 gradations on the scales.

Name	Task	Date

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High

APPENDIX C3

Multidimensional Driving Style Inventory

Hello,

We would be grateful if you can spare a few minutes of your time to answer this short questionnaire seriously and honestly. The questionnaire is confidential and your answers will be used for research purpose only. You as a participant will remain anonymous

The following are a list of statements concerning how people drive. Please read each statement carefully and indicate, on the following 6-point scale, to what extent the statement describes you. Rate your answers by the following scale:

1- not at all, 2 - very little, 3 - little, 4 - moderate, 5 - much, 6- very much							
1.	I often do relaxing activities while driving	1	2	3	4	5	6
2.	I often purposely tailgate other drivers	1	2	3	4	5	6
3.	I often blow my horn or 'flash' the car in front as a way of expressing my frustration.	1	2	3	4	5	6
4.	I feel I have control over driving	1	2	3	4	5	6
5.	I often drive through traffic lights that have just turned red.	1	2	3	4	5	6
6.	I usually enjoy the sensation of driving on the limit (dangerously)	1	2	3	4	5	6
7.	On a clear freeway, I usually drive at or a little below the speed limit	1	2	3	4	5	6
8.	While driving I try to relax myself	1	2	3	4	5	6
9.	When I am in a traffic jam and the lane next to mine starts to move, I try to move into that lane as soon as possible	1	2	3	4	5	6
10.	Driving usually makes me feel frustrated	1	2	3	4	5	6
11.	I often daydream to pass the time while driving	1	2	3	4	5	6
12.	I often swear at other drivers	1	2	3	4	5	6
13.	When a traffic light turns green and the car in front of me doesn’t get going, I just wait for a while until it moves	1	2	3	4	5	6
14.	I drive cautiously	1	2	3	4	5	6

15.	Sometimes lost in thought or distracted, I fail to notice someone waiting at a zebra crossing/pedestrian	1	2	3	4	5	6
16.	In a traffic jam, I think about ways to get through the traffic faster	1	2	3	4	5	6
17.	When a traffic light turns green and the car in front of me doesn't get going immediately, I try to urge the driver to move on	1	2	3	4	5	6
18.	At an intersection where I have to give right-of-way to oncoming traffic, I simply wait patiently for cross-traffic to pass	1	2	3	4	5	6
19.	When someone tries to skirt in front of me on the road I drive in an assertive way in order to prevent it	1	2	3	4	5	6
20.	I often fix my hair and/or makeup while driving	1	2	3	4	5	6
21.	I am often distracted or preoccupied, and suddenly realize that the vehicle ahead has slowed down, and I have to slam on the brakes to avoid a collision	1	2	3	4	5	6
22.	I like to take risks while driving	1	2	3	4	5	6
23.	I base my behavior on the motto "better safe than sorry"	1	2	3	4	5	6
24.	I like the thrill of flirting with death and disaster	1	2	3	4	5	6
25.	It worries me when driving in bad weather	1	2	3	4	5	6
26.	I often meditate while driving	1	2	3	4	5	6
27.	Lost in thoughts I often forget that my lights are on full beam until flashed by another motorist	1	2	3	4	5	6
28.	When someone does something on the road that annoys me, I flash them with the high beams	1	2	3	4	5	6
29.	I get a thrill out of breaking the law	1	2	3	4	5	6
30.	I often misjudge the speed of an oncoming vehicle when passing	1	2	3	4	5	6
31.	I feel nervous while driving	1	2	3	4	5	6
32.	I get impatient during rush hour	1	2	3	4	5	6
33.	I feel distressed while driving	1	2	3	4	5	6

34.	I often intend to switch on the windscreen wipers, but switch on the lights instead, or vice versa	1	2	3	4	5	6
35.	I often attempt to drive away from traffic lights in third gear (or on the neutral mode in automatic car)	1	2	3	4	5	6
36.	I often plan my route badly, so that I hit traffic that I could have avoided	1	2	3	4	5	6
37.	I often use muscle relaxation techniques while driving	1	2	3	4	5	6
38.	I plan long journeys in advance	1	2	3	4	5	6
39.	I often nearly (or actually) hit something due to Misjudging my gap in a parking lot	1	2	3	4	5	6
40.	I feel comfortable while driving	1	2	3	4	5	6
41.	I am always ready to react to unexpected maneuvers by other drivers	1	2	3	4	5	6
42.	I tend to drive cautiously	1	2	3	4	5	6
43.	I often honk my horn at others	1	2	3	4	5	6
44.	I usually enjoy the excitement of dangerous driving	1	2	3	4	5	6

APPENDIX C4

List of Songs from participants

Participant 01	Artist	Title
1	Edward Sharpe and Magnetic Zones	40 Day Dream
2	Rudimental Feat Ella Eyre	Waiting all night
3	Florence and the Machine	Rabbit Heart
4	Alt-J	Breeze Blocks
5	2 door cinema club	Something good
6	The Black keys	Sister
7	The Black keys	Hell of a season
8	Kings of Leon	Ragoo
9	Kasabian	Fire
10	The Black keys	Mind Eraser
11	Bombay Bicycle	What if
12	Flume & Chet Faker	Drop the Game
13	Woodkid	Ghost Lights
14	Derek Vincent Smith	Pretty Lights
15	Abel Tesfaye	The Weekend

Participant 02	Artist	Title
1	The South Texas Jazz Quartet	Deep in the heart of Texas
2	Jake Koelzer	How are we meant
3	Coin	Its okay
4	Saints of Valory	Kids
5	Paper Lights	On your way
6	Julie Fowlis	Bothan Airigh Am Braigh Raithneach
7	Owl City	The Bird & The Worm
8	Mindy Gledhill	Crazy
9	Green River Ordinance	It Aint love
10	Saints of Valory	Long Time Coming
11	Matt Wertz	Snow Globe
12	Vertical Church Band	The Rock Won’t Move
13	Bronze Radio Return	Up, on and Over

Participant 03	Artist	Title
1	Black Coffee	Gardens of Eden
2	DJ clock	Kiss & say goodbye
3	DJ Christos	Your Kiss
4	Charles Webster	The cure&the cause
5	DJ Kent	Sunrise
6	DJ Christos	Shana
7	DJ Christos	Andy Compton
8	Unknown artist	Love someone
9	340 ml feat Thandiswa	Make it happen
10	Ralf Gum ft Hugh M	With her hand
11	Ralf Gum ftMonique	The Pap
12	Ralf Gum ft Portia	Free

Participant 04	Artist	Title
1	2 Pac	Changes
2	Elton John	Sad Songs (say so Much)
3	Leona Lewis	Outta My head
4	Elton John	Circle of Life
5	Zedd	Stay the Night
6	Anthony Hamilton	Fine Again
7	Chris Brown	Remember My Name
8	Bob Carlisle	Butterfly Kisses
9	Bucie	Easy To Love
10	Bucie	Kiss You
11	Akon	Freedom
12	James Blunt	Billy

Participant 05	Artist	Title
1	Mika	Lollipop
2	Queen	Fat Bottomed Girls
3	Queen	I want it all/We will Rock
4	Queen	Don’t Stop me now
5	Queen	Bohemian Rhapsody
6	Queen	We are the champions
7	Queen	Bicycle
8	My Chemical Romance	Dead
9	My Chemical Romance	House of wolves
10	Jason Mraz	I’m yours
11	Eminem	Just lose it
12	Eminem	Lose Yourself

Participant 06	Artist	Title
1	Jaheim	Everywhere I am
2	AKA	All eyes on me
3	Kelly Rowland	Train on the track
4	Amel Larriux	No one else
5		
6	Jub-Jub	Phind'ukhulume
7	Riky Rick	Boss Zonke
8	Brandy and various artists	Missing you
9	Artist	
10	Chris Malinchak	So good to me
11	D'Angelo	Voodoo
12	Emeli Sande	

Participant 07	Artist	Title
1	Dsoh 4631_lb house mix	No title, hour long mix

Participant 08	Artist	Title
1	Icona Pop	All night
2	Afrojack	Do or die
3	Nadia Ali	Rapture
4	Flo Rida	Wild Ones
5	Seinabo Sey	Younger (Kygo remix)
6	Netsky	We can only live today
7	2pac vs Notorious B.I.G	Hold on be strong vs Big Poppa
8	John Denver	Country Roads
9	Boney M	Going back west
10	Brian Adams	Summer 69
11	Joan Jett The Blackhearts	I love rock and roll

Participant 09	Artist	Title
1	Icona Pop	All Night
2	Afrojack	Do or die
3	Nadia Ali	Rapture
4	Flo Rida	Wild ones
5	Seinabo Sey	Younger
6	Netsky	We can only live Today
7	2pac vs Notorious B.I.G	Hold on be strong vs Big poppa
8	John Denver	Country Roads
9	Boney M	Going back west
10	Brian Adams	Summer 69
11	Joan Jett The blackhearts	I love rock and roll

Participant 10	Artist	Title
1	Skylar Grey	Addicted to love
2	George Ezra	Blame it on me
3	Us and Our daughter	Carry you away
4	Fall out boy	Centuries
5	Gavin DeGraw	Fire
6	Kelly Clarkson	Heartbeat song
7	Kiesza	Hideaway
8	Nick Jones	Jealous
9	Sheppard	Let me down easy
10	NONONO	Pumpin Blood
11	Ben Haenow	Small things
12	New radicals	Someday we'll know

Participant 11	Artist	Title
1	Orianthi	According to You
2	Lost Prophets	Rooftops
3	Daughtry	You don't belong
4	Fall out boys	Americas Sweetheart
5	Thirty second to mars	Kings and Queens
6	Five for fighting	America Town
7	Prime circle	Consider Me
8	Nine boys	Absolutely
9	Sum 41	Rhythms
10	Liquido	Narcotic
11	Busted	Year 3000
12	The red jumpsuit apparatus	Pen and Paper

Participant 12	Artist	Title
1	The chariot	Forget
2	The Notorious BIG	Intro
3	Haste the Day	68
4		
5	Close your eyes	A Proclamation
6	Blink 182	Anthem Pt 2
7	Jurassic 5	Back 4 U
8	The used	Blood on My hands
9	Jamie T	Brand New Bass Guitar
10	The used	Dark Days

Participant 13	Artist	Title
1	Adrian Lux ft Kaelyn Behr	Sooner or later
2	Afi	17 crimes
3	Atlas Bound	Talk
4	A-Trak ft Andrew Wyant	
5	Avicii	The nights
6	Ben Howard	Promise
7	Called out in the dark	Snow patrol
8	Crash test dummies	Afternoons and go coffee spoons
9	Ed Sheeran+Rudimental	Blood stream
	Feder	Goodbye

Participant 14	Artist	Title
1	Cody Simpson	La Da Dee
2	Imagine dragons	Radioactive
3	Milky chance	Flashed Junk Mind
4	James Blunt	Same Mistake
5		Keep on moving
6		Cotton Fields
7	Alex and Sierra	Little do you know
8	One Republic	Counting Stars
9	Imagine Dragrons	Demons
10	Chuck Norris Dub	Downunder
11	Karlien Van Jaarsveld	Feeverhaal
12	Jeremy Loops	Down south

Participant 15	Artist	Title
1	Ed Sheeran	Don’t
2	Tiesto	Footprints
3	2pac	Changes
4	Oasis	Wonderfall
5	3lau ft bright lights	How you love me
6	Tietso	Written in reverse
7	Tietso	Let’s go
8	Afro jack	We’ll be ok
9	South Street players	Who keeps changing your mind
10	Afro jack	Keep our love alive
11	Ten walls	Walking with elephants
12	Madeline Juno	Symphathy

Participant 16	Artist	Title
1	Gold fish	1 moonwalk away
2	Ingrid Michaelson	Girls chase boys
3	Alt-J	Left hand free
4	Amerie	I thing
5	Awolnation	Sail
6	Banks	Goddess
7	Calvin Harris ft Florence Welch	Sweet thing
8	Chet Faker	Fear like you
9	Chet Faker	I'm into you
10	Chet Faker	Talk is cheap
11	Christina Aguilera	Genie in a bottle
12	Daughter	Run
13	David Guetta	She wolf

Participant 17	Artist	Title
1	Milky Chance	Flashed Junk Mind
2	Alesso	Sweet escape
3	Ariana grande ft Zeed	Break free
4	Becky G	Shower
5	American author	Best day of life
6	George Ezra	Budapest
7	Calvin Harris ft Ellie Goulding	Outside
8	Charli xcx	Boom Clap
9	Clean Bandit	Rather Be
10	Cold Play	A sky full of stars
11	G.R.L	Ugly heart
12	I'm an Albatraoz	AronChupa

Participant 18	Artist	Title
1	The Lumineers	Flowers in your hair
2	The Lumineers	Classy girls
3	Angus and Julia Stone	Paper Aeroplane
4	The Lumineers	Submarines
5	Crystal Fighters	You and I
6	Artic Monkeys	Arabella
7	The Lumineers	Dead Sea
8	Xavier Rudd	Solace
9	Jeremy Loops	Trip fox
10	Arti Monkeys	

Participant 19	Artist	Title
1	Skylar Grey	Addicted to love
2	George Ezra	Blame it on me
3	Us and Our daughter	Carry you away
4	Fall out boy	Centuries
5	Gavin DeGraw	Fire
6	Kelly Clarkson	Heartbeat song
7	Kiesza	Hideaway
8	Nick Jones	Jealous
9	Sheppard	Let me down easy
10	NONONO	Pumpin Blood
11	Ben Haenow	Small things
12	New radicals	Someday we'll know

Participant 20	Artist	Title
1	Bruno Mars	Young girls
2	Dj Cleo	Fallen
3	Dj Snake lil Jon	Turn down for what
4	Ed Sheeran	Thinking out loud
5	Ellie Goulding	Love me like you do
6	Fifth Harmony ft Kid ink	Worth it
7	John Legend	All of me
8	Mark ronson ft Bruno mars	Uptown funk
9	Maroon 5	Animal
10	MiCasa	Your body

Participant 21	Artist	Title
1	Bruno Mars	Young girls
2	Dj Cleo	Fallen
3	Dj Snake lil Jon	Turn down for what
4	Ed Sheeran	Thinking out loud
5	Ellie Goulding	Love me like you do
6	Fifth Harmony ft Kid ink	Worth it
7	John Legend	All of me
8	Mark ronson ft Bruno mars	Uptown funk
9	Maroon 5	Animal
10	MiCasa	Your body

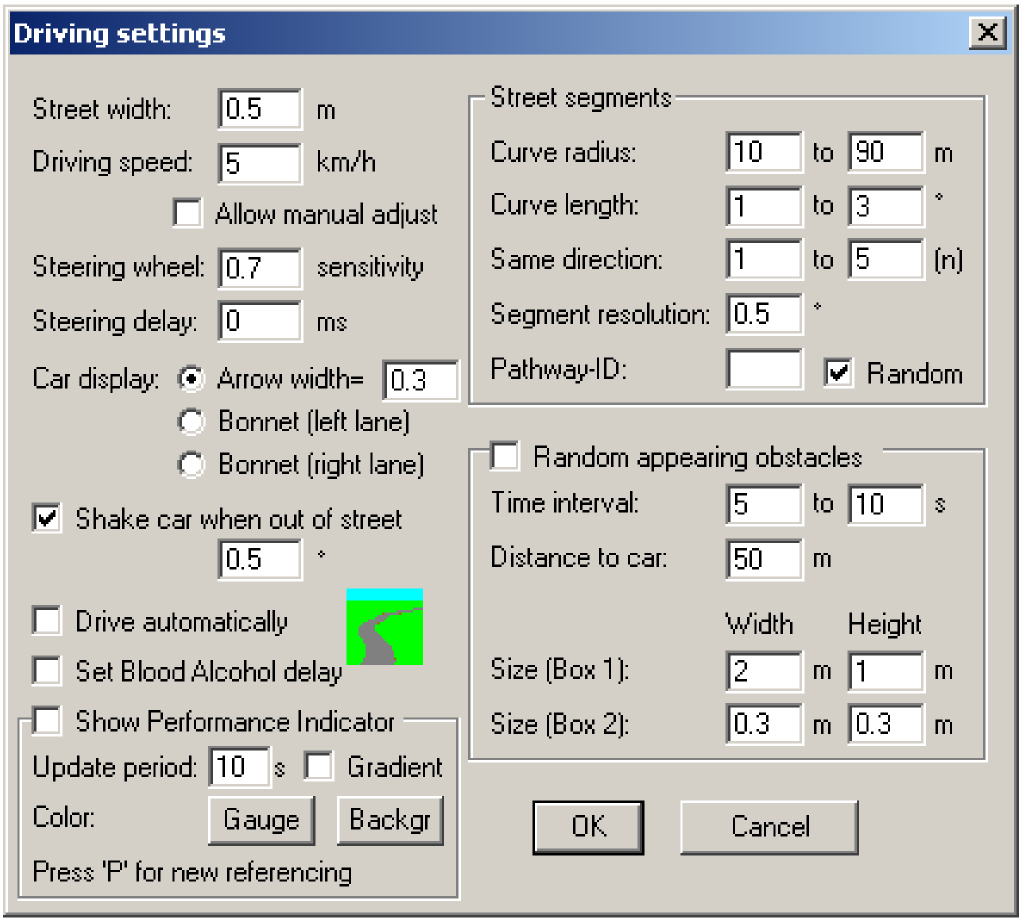
Participant 23	Artist	Title
1	Sigma	Nobody to Love
2	Hozier	Take me to church
3	Charli XCX	Doing it
4	Avicii	The nights
5	Sam Smith	I'm not the only one
6	Jess Glynne	Clean Bandit
7	Sigma ft Paloma faith	Changing
8	George Ezra	Blame it on me
9	Echo Smith	Cool Kids
10	Calvin Harris ft Ellie Goulding	Outside

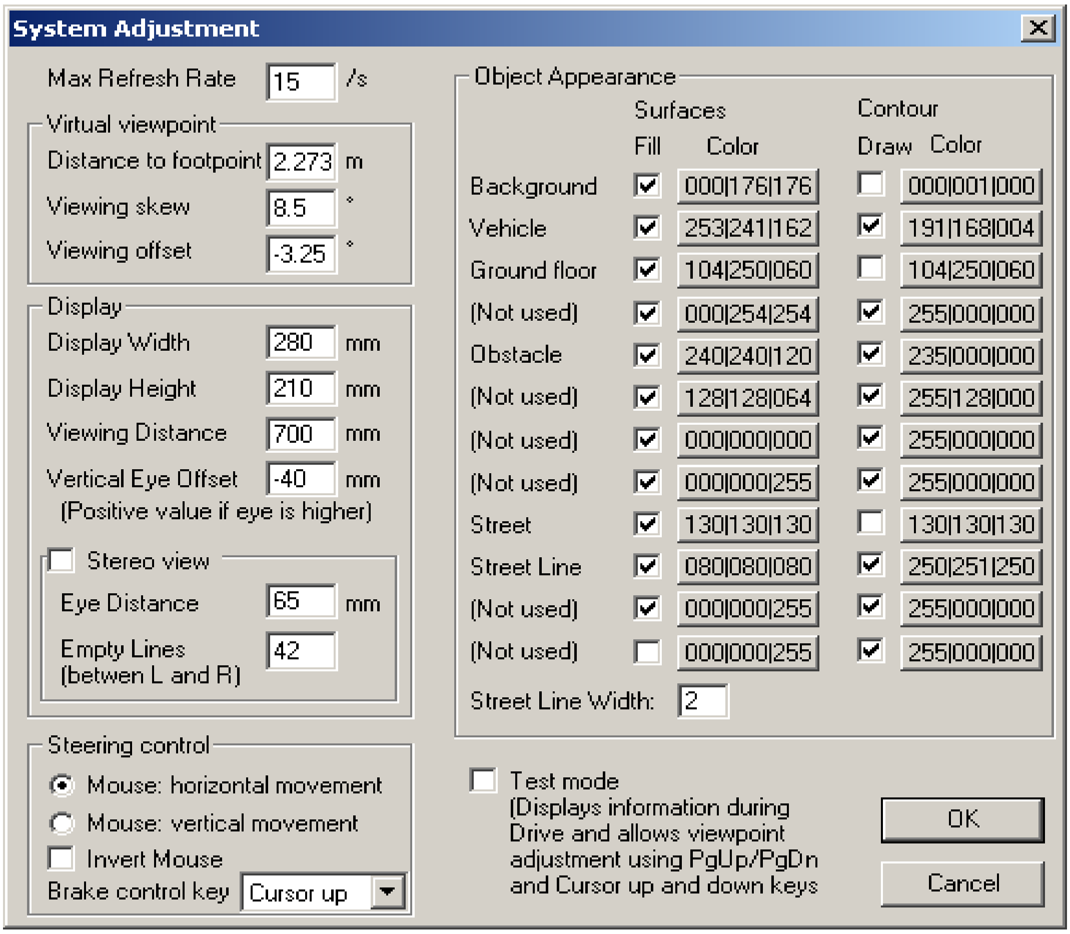
Participant 24	Artist	Title
1	50 cent	21 questions
2	Aaron Smith	Dance
3	Alesso	Hero
4	Alive	
5	Anna Graceman	Words
6	Arcadia	Psych punkz remix
7	Back to Earth	
8	Benjamin Francis	snowship
9	Breakdlaw	Paint me like a French girl
10	Daniel Fernandes	After all
11	Deorro	Five Hours

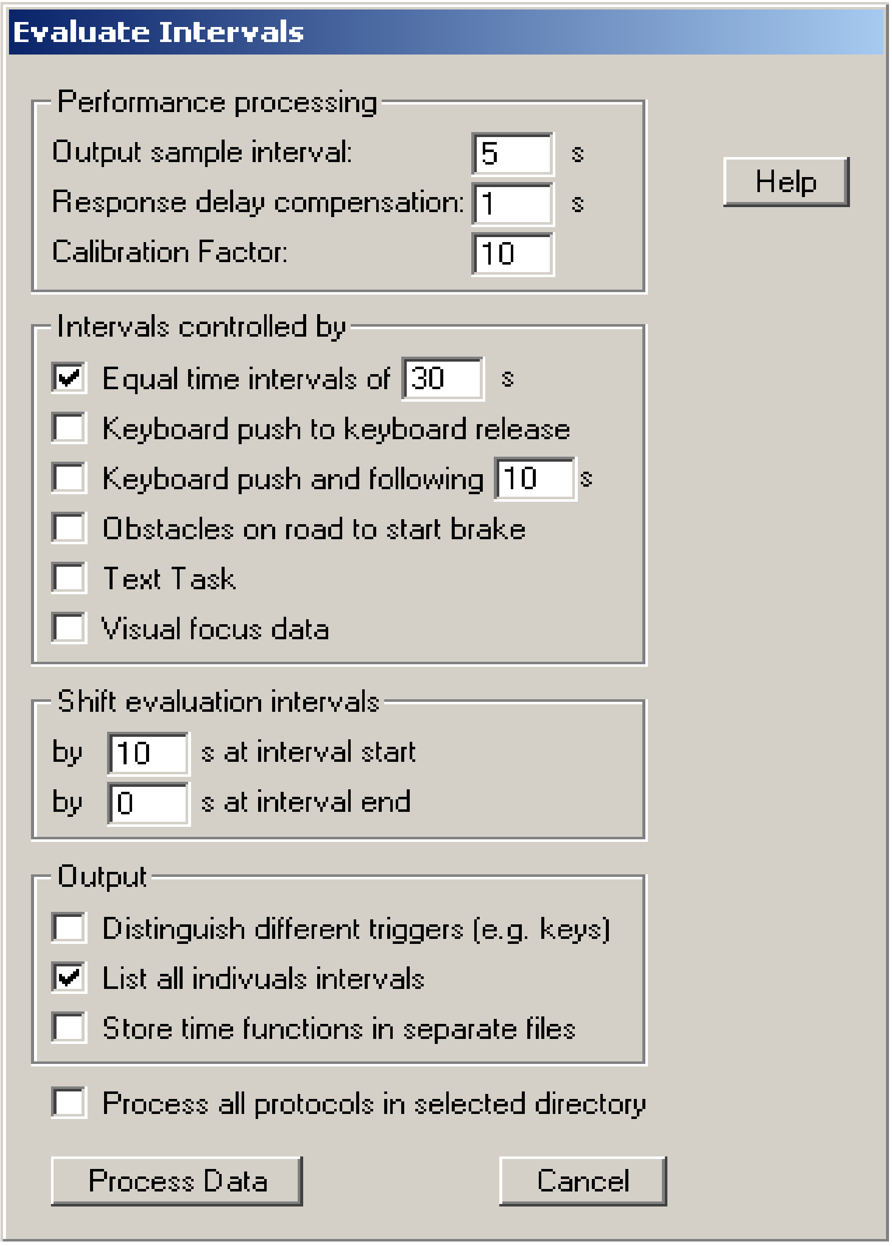
Participant 25	Artist	Title
1	Imagine Dragons	Radioactive
2	James Blunt	Same Mistake
3	Cody Simpson	La Da Dee
4	Rudimental	Waiting All Night
5	Kings of Leon	Ragoo
6	Flo Rida	Wild ones
7	George Ezra	Blame it on me
8	Awolnation	Sail
9	David Guetta	She Wolf
10	Cold play	A sky full of stars
11	Sheppard	Let me down easy

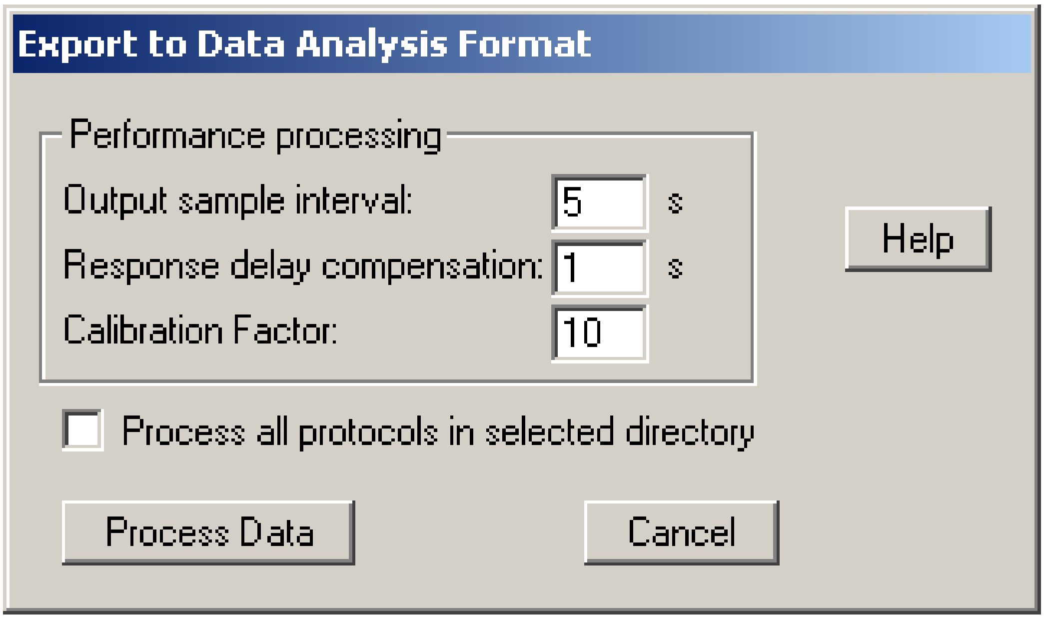
APPENDIX C5

Driving Simulator System Parameters




System Adjustment
Max Refresh Rate 15 /s
Virtual viewpoint
Distance to footpoint 2.273 m
Viewing skew 8.5 °
Viewing offset -3.25 °
Display
Display Width 280 mm
Display Height 210 mm
Viewing Distance 700 mm
Vertical Eye Offset -40 mm
(Positive value if eye is higher)
Stereo view
Eye Distance 65 mm
Empty Lines (betwen L and R) 42
Steering control
Mouse: horizontal movement
Mouse: vertical movement
Invert Mouse
Brake control key Cursor up
Object Appearance
Surfaces Fill Color
Contour Draw Color
Background 000|176|176 000|001|000
Vehicle 253|241|162 191|168|004
Ground floor 104|250|060 104|250|060
(Not used) 000|254|254 255|000|000
Obstacle 240|240|120 235|000|000
(Not used) 128|128|064 255|128|000
(Not used) 000|000|000 255|000|000
(Not used) 000|000|255 255|000|000
Street 130|130|130 130|130|130
Street Line 080|080|080 250|251|250
(Not used) 000|000|255 255|000|000
(Not used) 000|000|255 255|000|000
Street Line Width: 2
Test mode
(Displays information during Drive and allows viewpoint adjustment using PgUp/PgDn and Cursor up and down keys
OK
Cancel


Evaluate Intervals
Performance processing
Output sample interval: 5 s
Response delay compensation: 1 s
Calibration Factor: 10
Help
Intervals controlled by
Equal time intervals of 30 s
Keyboard push to keyboard release
Keyboard push and following 10 s
Obstacles on road to start brake
Text Task
Visual focus data
Shift evaluation intervals
by 10 s at interval start
by 0 s at interval end
Output
Distinguish different triggers (e.g. keys)
List all indivuals intervals
Store time functions in separate files
Process all protocols in selected directory
Process Data
Cancel


Export to Data Analysis Format
Performance processing
Output sample interval:
5
s
Response delay compensation:
1
s
Calibration Factor:
10
Help
Process all protocols in selected directory
Process Data
Cancel

APPENDIX D

Data Collection Sheet

Participant code: **Personality trait:**

Gender: **Date:**

Transition start Time		**Baseline start time**		**Condition 1 start time**	
Transition end Time		**Baseline end time**		**Condition 1 end time**	

Transition start Time		**Baseline start time**		**Condition 2 start time**	
Transition end Time		**Baseline end time**		**Condition 2 end time**	

Transition start time		**Baseline start time**		**Condition 3 start time**	
Transition end time		**Baseline end time**		**Condition 3 end time**	

<u>Tracking deviation</u>

Driving performance	**Cond 1**	**Cond 2**	**Cond 3**
File Name			

APPENDIX D2

Permutation Table

Participant code	Without Music Cond 1	With Moderate Music Cond 2	With Loud Music Cond 3
01	Cond 1	Cond 2	Cond 3
02	Cond 1	Cond 3	Cond 2
03	Cond 2	Cond 1	Cond 3
04	Cond 2	Cond 3	Cond 1
05	Cond 3	Cond 1	Cond 2
06	Cond 3	Cond 2	Cond 1
07	Cond 1	Cond 2	Cond 3
08	Cond 1	Cond 3	Cond 2
09	Cond 2	Cond 1	Cond 3
10	Cond 2	Cond 3	Cond 1
11	Cond 3	Cond 1	Cond 2
12	Cond 3	Cond 2	Cond 1
13	Cond 1	Cond 2	Cond 3
14	Cond 1	Cond 3	Cond 2
15	Cond 2	Cond 1	Cond 3
16	Cond 2	Cond 3	Cond 1
17	Cond 3	Cond 1	Cond 2
18	Cond 3	Cond 2	Cond 1
19	Cond 1	Cond 2	Cond 3
20	Cond 1	Cond 3	Cond 2
21	Cond 2	Cond 1	Cond 3
22	Cond 2	Cond 3	Cond 1
23	Cond 3	Cond 1	Cond 2
24	Cond 3	Cond 2	Cond 1
25	Cond 1	Cond 2	Cond 3
26	Cond 1	Cond 3	Cond 2
27	Cond 2	Cond 1	Cond 3
28	Cond 2	Cond 3	Cond 1
29	Cond 3	Cond 1	Cond 2
30	Cond 3	Cond 2	Cond 1

APPENDIX E

DATA REDUCTION & STATISTICAL TABLES

Driving Performance Parameters-Tracking deviation

Effect	Repeated Measures Analysis of Variance (tracking deviation (m) in driving performance) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 43.05908				
	SS	dF	MS	F	p
Intercept	2193	1	2192.559	1.182556	0.288101
Error	42644	23	1854.085		
CONDITION	4073	2	2036.688	1.095282	0.343008
Error	85538	46	1859.511		
INTERVAL	43071	45	957.137	1.051494	0.381905
Error	942123	1035	910.264		
CONDITION*INTERVAL	86217	90	957.969	1.052450	0.350251
Error	1884171	2070	910.228		

Driving Performance Parameters-Reaction Time

Effect	Repeated Measures Analysis of Variance (driving performance) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 6.415863				
	SS	dF	MS	F	p
Intercept	186.373	1	186.3729	4.527646	0.046664
Error	782.103	19	41.1633		
CONDITION	49.167	2	24.5837	0.533040	0.591142
Error	1752.552	38	46.1198		
INTERVAL	188.329	45	4.1851	1.036104	0.409218
Error	3453.568	855	4.0393		
CONDITION*INTERVAL	356.003	90	3.9556	0.976434	0.543531
Error	6927.305	1710	4.0511		

Driving Performance Parameter: Age Effect

Effect	Repeated Measures Analysis of Variance (driving performance) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 6.591315				
	SS	dF	MS	F	p
Intercept	1.907	1	1.90694	0.043893	0.836406
Age	0.085	1	0.08497	0.001956	0.965213
Error	782.018	18	43.44543		
CONDITION	36.874	2	18.43690	0.387137	0.681791
CONDITION*Age	38.098	2	19.04882	0.399986	0.673272
Error	1714.454	36	47.62372		
INTERVAL	36.945	45	0.82100	0.194796	1.000000
INTERVAL*Age	39.668	45	0.88152	0.209153	1.000000
Error	3413.899	810	4.21469		
CONDITION*INTERVAL	79.708	90	0.88565	0.209706	1.000000
CONDITION*INTERVAL*Age	85.607	90	0.95118	0.225225	1.000000
Error	6841.698	1620	4.22327		

Heart Rate frequency: Age

Effect	Repeated Measures Analysis of Variance (HRF age) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 53.08971				
	SS	dF	MS	F	p
Intercept	33135.75	1	33135.75	11.75645	0.002293
Age	734.68	1	734.68	0.26066	0.614531
Error	64825.91	23	2818.52		
CONDITION	111.80	2	55.90	0.21903	0.804127
CONDITION*Age	93.64	2	46.82	0.18345	0.833003
Error	11740.00	46	255.22		
INTERVAL	11.40	8	1.43	0.22328	0.986381

INTERVAL*Age	17.27	8	2.16	0.33802	0.950250
Error	1174.80	184	6.38		
CONDITION*INTERVAL	19.46	16	1.22	0.41563	0.978366
CONDITION*INTERVAL*Age	19.61	16	1.23	0.41876	0.977520
Error	1077.07	368	2.93		

Heart rate variability: SDNN (ms)-Age

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 100.7290				
	SS	dF	MS	F	p
Intercept	3021.6	1	3021.62	0.297804	0.590517
Age	19208.0	1	19208.01	1.893096	0.182104
Error	233366.0	23	10146.35		
CONDITION	1196.5	2	598.24	1.072142	0.350672
CONDITION*Age	1327.8	2	663.92	1.189841	0.313459
Error	25667.5	46	557.99		
INTERVAL	233.0	8	29.13	1.078557	0.379984
INTERVAL*Age	196.7	8	24.59	0.910667	0.508816
Error	4969.0	184	27.01		
CONDITION*INTERVAL	302.8	16	18.92	0.711742	0.782384
CONDITION*INTERVAL*Age	347.1	16	21.69	0.815854	0.667648
Error	9784.1	368	26.59		

Heart Rate Variability: PNN30

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 88.78687				
	SS	dF	MS	F	p
Intercept	1386392	1	1386392	175.8688	0.000000
Error	189195	24	7883		
CONDITION	807	2	404	0.4095	0.666297
Error	47323	48	986		
INTERVAL	221	8	28	1.1265	0.347105
Error	4705	192	25		
CONDITION*INTERVAL	310	16	19	0.9167	0.550063
Error	8129	384	21		

Heart rate variability: PNN30-Age

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 79.05588				
	SS	dF	MS	F	p
Intercept	768635.3	1	768635.3	122.9850	0.000000
Age	82947.5	7	11849.6	1.8960	0.133179
Error	106247.1	17	6249.8		
CONDITION	1139.5	2	569.8	0.5313	0.592636
CONDITION*Age	10861.9	14	775.8	0.7235	0.736669
Error	36461.5	34	1072.4		
INTERVAL	93.1	8	11.6	0.4202	0.907295
INTERVAL*Age	937.4	56	16.7	0.6042	0.983096
Error	3767.9	136	27.7		
CONDITION*INTERVAL	225.5	16	14.1	0.5961	0.886009
CONDITION*INTERVAL*Age	1696.7	112	15.1	0.6406	0.996387
Error	6432.0	272	23.6		

Heart rate variability: PNN30-Sex

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 90.51347				
	SS	dF	MS	F	p
Intercept	1343712	1	1343712	164.0135	0.000000
Sex	763	1	763	0.0931	0.763016
Error	188432	23	8193		
CONDITION	790	2	395	0.4106	0.665628
CONDITION*Sex	3050	2	1525	1.5847	0.215996
Error	44273	46	962		
INTERVAL	220	8	28	1.0989	0.365912
INTERVAL*Sex	100	8	12	0.4989	0.855959
Error	4605	184	25		
CONDITION*INTERVAL	253	16	16	0.7525	0.739096
CONDITION*INTERVAL*Sex	399	16	25	1.1869	0.275670
Error	7730	368	21		

Heart Rate Variability: PNN50

Effect	Repeated Measures Analysis of Variance (PNN50) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 88.27695				
	SS	dF	MS	F	p
Intercept	434295.0	1	434295.0	55.73014	0.000000
Error	187027.7	24	7792.8		
CONDITION	1073.5	2	536.8	0.56783	0.570513
Error	45373.0	48	945.3		
INTERVAL	257.5	8	32.2	1.26728	0.262739
Error	4876.7	192	25.4		
CONDITION*INTERVAL	422.1	16	26.4	1.42891	0.124589
Error	7089.2	384	18.5		

Heart rate variability: PNN50-Age

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 78.96407				
	SS	dF	MS	F	p
Intercept	236140.4	1	236140.4	37.87138	0.000011
Age	81027.2	7	11575.3	1.85641	0.140786
Error	106000.5	17	6235.3		
CONDITION	1513.4	2	756.7	0.72992	0.489345
CONDITION*Age	10125.5	14	723.3	0.69765	0.760850
Error	35247.5	34	1036.7		
INTERVAL	73.2	8	9.1	0.30135	0.964379
INTERVAL*Age	747.8	56	13.4	0.43987	0.999646
Error	4128.9	136	30.4		
CONDITION*INTERVAL	274.4	16	17.2	0.84015	0.639219
CONDITION*INTERVAL*Age	1536.3	112	13.7	0.67190	0.991925
Error	5552.9	272	20.4		

Heart rate variability: PNN50-Sex

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 89.84827				
	SS	dF	MS	F	p
Intercept	426485.7	1	426485.7	52.83053	0.000000
Sex	1355.3	1	1355.3	0.16789	0.685789
Error	185672.4	23	8072.7		
CONDITION	1180.4	2	590.2	0.63910	0.532386
CONDITION*Sex	2894.7	2	1447.4	1.56735	0.219532
Error	42478.3	46	923.4		
INTERVAL	262.8	8	32.8	1.27124	0.260925
INTERVAL*Sex	122.1	8	15.3	0.59040	0.785060
Error	4754.7	184	25.8		
CONDITION*INTERVAL	391.5	16	24.5	1.33799	0.170928
CONDITION*INTERVAL*Sex	358.8	16	22.4	1.22596	0.245001
Error	6730.5	368	18.3		

Heart rate variability: HF power (ms^2)

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 5281.011				
	SS	dF	MS	F	p
Intercept	430568531.79	1	430568531.8	15.43860	0.000630
Error	669338060	24	27889086		
CONDITION	765944	2	382972	0.19537	0.823182
Error	94092141	48	1960253		
INTERVAL	9225520	8	1153190	1.25906	0.267193
Error	175855956	192	915916		
CONDITION*INTERVAL	12082344	16	755146	0.85112	0.626683
Error	340700856	384	887242		

Heart rate variability: HF power (ms²)-Personality traits

Effect	Repeated Measures Analysis of Variance (HF power) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 5709.319				
	SS	dF	MS	F	p
Intercept	12836309	1	12836309	0.393796	0.537780
Extraversion	27073410	1	27073410	0.830566	0.373527
Agreeableness	245485	1	245485	0.007531	0.931753
Conscientiousness	188691	1	188691	0.005789	0.940148
Neuroticism	18960731	1	18960731	0.581683	0.455019
Openness	8975703	1	8975703	0.275359	0.605828
Error	619330338	19	32596334		
CONDITION	100403	2	50201	0.022804	0.977467
CONDITION*extraversion	6225566	2	3112783	1.414009	0.255671
CONDITION*agreeableness	6611320	2	3305660	1.501625	0.235690
CONDITION*Conscientiousness	110245	2	55123	0.025040	0.975287
CONDITION*neuroticism	113483	2	56742	0.025775	0.974571
CONDITION*openness	2008156	2	1004078	0.456111	0.637168
Error	83652785	38	2201389		
INTERVAL	1345259	8	168157	0.152048	0.996281
INTERVAL*extraversion	1053848	8	131731	0.119111	0.998439
INTERVAL*agreeableness	3992843	8	499105	0.451292	0.888217
INTERVAL*Conscientiousness	510483	8	63810	0.057698	0.999895
INTERVAL*neuroticism	915827	8	114478	0.103512	0.999063
INTERVAL*openness	263576	8	32947	0.029791	0.999992
Error	168103921	152	1105947		
CONDITION*INTERVAL	3652280	16	228267	0.217539	0.999496
CONDITION*INTERVAL*extraversion	2095055	16	130941	0.124787	0.999988
CONDITION*INTERVAL*agreeableness	11532605	16	720788	0.686912	0.806808
CONDITION*INTERVAL*Conscientiousness	714355	16	44647	0.042549	1.000000
CONDITION*INTERVAL*neuroticism	3282375	16	205148	0.195507	0.999748
CONDITION*INTERVAL*openness	572795	16	35800	0.034117	1.000000
Error	318992190.8	304	1049316		

Heart rate variability: HF power (ms^2)-Age

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 4737.195				
	SS	dF	MS	F	p
Intercept	271536381.9	1	271536381.9	12.10000	0.002875
Age	287840670	7	41120096	1.83236	0.145626
Error	381497390	17	22441023		
CONDITION	1807259	2	903629	0.48251	0.621394
CONDITION*Age	30418012	14	2172715	1.16016	0.347116
Error	63674129	34	1872768		
INTERVAL	1883439	8	235430	0.22186	0.986491
INTERVAL*Age	31537940	56	563178	0.53072	0.995947
Error	144318016	136	1061162		
CONDITION*INTERVAL	2188836	16	136802	0.12495	0.999988
CONDITION*INTERVAL*Age	42888585	112	382934	0.34974	1.000000
Error	297812271	272	1094898		

Heart rate variability: HF power (ms^2)-Sex

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 5378.096				
	SS	dF	MS	F	p
Intercept	397066865	1	397066864.6	13.72798	0.001166
Sex	4087889	1	4087889	0.14133	0.710405
Error	665250171	23	28923920		
CONDITION	1489908	2	744954	0.38446	0.682984
CONDITION*Sex	4960134	2	2480067	1.27993	0.287771
Error	89132007	46	1937652		
INTERVAL	6665422	8	833178	0.89828	0.519100

INTERVAL*Sex	5190780	8	648848	0.69954	0.691693
Error	170665176	184	927528		
CONDITION*INTERVAL	8315867	16	519742	0.57694	0.901016
CONDITION*INTERVAL*Sex	9181910	16	573869	0.63702	0.853593
Error	331518945.2	368	900867		

Heart rate Variability-HF: Centre Frequency (Hz)

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 5281.011				
	SS	dF	MS	F	p
Intercept	430568531.79	1	430568531.8	15.43860	0.000630
Error	669338060	24	27889086		
CONDITION	765944	2	382972	0.19537	0.823182
Error	94092141	48	1960253		
INTERVAL	9225520	8	1153190	1.25906	0.267193
Error	175855956	192	915916		
CONDITION*INTERVAL	12082344	16	755146	0.85112	0.626683
Error	340700856	384	887242		

Heart rate variability: LF power

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 8177.496				
	SS	dF	MS	F	p
Intercept	1.474537E+09	1	1.474537E+09	22.05032	0.000090
Error	1.604915E+09	24	6.687145E+07		
CONDITION	5.247513E+06	2	2.623756E+06	0.14651	0.864099
Error	8.595833E+08	48	1.790799E+07		
INTERVAL	2.038366E+08	8	2.547958E+07	1.68918	0.103176
Error	2.896124E+09	192	1.508398E+07		
CONDITION*INTERVAL	2.251930E+08	16	1.407456E+07	0.90224	0.566886
Error	5.990230E+09	384	1.559956E+07		

Heart rate variability: LF power- Personality

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 8977.994				
	SS	dF	MS	F	p
Intercept	1.106442E+05	1	110644	0.001373	0.970832
Extraversion	3.006735E+07	1	30067353	0.373024	0.548598
agreeableness	2.694305E+06	1	2694305	0.033426	0.856869
Conscientiousness	7.106084E+06	1	7106084	0.088160	0.769751
Neuroticism	1.382213E+06	1	1382213	0.017148	0.897191
Openness	5.742775E+06	1	5742775	0.071246	0.792406
Error	1.531483E+09	19	80604379		
CONDITION	8.003006E+05	2	400150	0.019347	0.980848
CONDITION*extraversion	2.577038E+07	2	12885189	0.622995	0.541724
CONDITION*agreeableness	3.598892E+07	2	17994461	0.870027	0.427118
CONDITION*Conscientiousness	8.886862E+05	2	444343	0.021484	0.978757
CONDITION*neuroticism	1.981345E+07	2	9906727	0.478987	0.623099
CONDITION*openness	7.302735E+06	2	3651367	0.176543	0.838847
Error	7.859405E+08	38	20682645		
INTERVAL	1.685402E+07	8	2106752	0.116318	0.998568
INTERVAL*extraversion	1.136381E+07	8	1420476	0.078427	0.999664
INTERVAL*agreeableness	8.719614E+07	8	10899518	0.601782	0.775331
INTERVAL*Conscientiousness	5.968303E+06	8	746038	0.041190	0.999971
INTERVAL*neuroticism	1.521271E+07	8	1901589	0.104990	0.999013
INTERVAL*openness	1.810403E+06	8	226300	0.012494	1.000000
Error	2.753033E+09	152	18112062		
CONDITION*INTERVAL	6.398077E+07	16	3998798	0.215668	0.999523
CONDITION*INTERVAL*extraversion	3.407837E+07	16	2129898	0.114872	0.999994
CONDITION*INTERVAL*agreeableness	2.293748E+08	16	14335926	0.773183	0.715819
CONDITION*INTERVAL*Conscientiousness	1.100487E+07	16	687805	0.037096	1.000000
CONDITION*INTERVAL*neuroticism	3.486989E+07	16	2179368	0.117540	0.999992
CONDITION*INTERVAL*openness	2.449926E+06	16	153120	0.008258	1.000000
Error	5.636601E+09	304	18541452		

Heart rate variability: LF power-Age

Effect	Repeated Measures Analysis of Variance (LF power) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 8210.937				
	SS	dF	MS	F	p
Intercept	1.707674E+07	1	17076740	0.253291	0.619553
Age	5.426633E+07	1	54266334	0.804906	0.378926
Error	1.550649E+09	23	67419500		
CONDITION	2.775724E+07	2	13878618	0.765879	0.470762
CONDITION*Age	2.600927E+07	2	13004635	0.717649	0.493279
Error	8.335740E+08	46	18121175		
INTERVAL	1.256643E+08	8	15708042	1.034748	0.411509
INTERVAL*Age	1.029041E+08	8	12863011	0.847335	0.562239
Error	2.793220E+09	184	15180543		
CONDITION*INTERVAL	2.353826E+08	16	14711414	0.935310	0.528622
CONDITION*INTERVAL*Age	2.019883E+08	16	12624269	0.802615	0.682869
Error	5.788241E+09	368	15728917		

Heart rate variability: LF power-Sex

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 8255.009				
	SS	dF	MS	F	p
Intercept	1.324806E+09	1	1.324806E+09	19.44094	0.000203
Sex	3.757555E+07	1	3.757555E+07	0.55140	0.465261
Error	1.567339E+09	23	6.814519E+07		
CONDITION	1.857934E+06	2	9.289671E+05	0.05147	0.949887
CONDITION*Sex	2.934591E+07	2	1.467296E+07	0.81297	0.449810
Error	8.302374E+08	46	1.804864E+07		
INTERVAL	1.518776E+08	8	1.898470E+07	1.24005	0.278008

INTERVAL*Sex	7.915183E+07	8	9.893978E+06	0.64626	0.738031
Error	2.816972E+09	184	1.530963E+07		
CONDITION*INTERVAL	1.536215E+08	16	9.601345E+06	0.60400	0.880853
CONDITION*INTERVAL*Sex	1.404141E+08	16	8.775884E+06	0.55207	0.917720
Error	5.849815E+09	368	1.589624E+07		

Heart Rate variability: LF centre frequency-Age

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: .0292867				
	SS	dF	MS	F	p
Intercept	3.728818	1	3.728818	4347.389	0.000000
Age	0.012442	7	0.001777	2.072	0.104157
Error	0.014581	17	0.000858		
CONDITION	0.000374	2	0.000187	1.557	0.225326
CONDITION*Age	0.002088	14	0.000149	1.242	0.292296
Error	0.004082	34	0.000120		
INTERVAL	0.000342	8	0.000043	1.934	0.059754
INTERVAL*Age	0.001739	56	0.000031	1.406	0.057298
Error	0.003004	136	0.000022		
CONDITION*INTERVAL	0.000295	16	0.000018	0.665	0.827359
CONDITION*INTERVAL*Age	0.002706	112	0.000024	0.871	0.798141
Error	0.007542	272	0.000028		

Heart rate variability: LF power relative to (LF+HF)-Personality Traits

Effect	Repeated Measures Analysis of Variance (Copy of Eye Movements) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 36.41753				
	SS	dF	MS	F	p
Intercept	366.68	1	366.685	0.276485	0.605432
extraversion	349.36	1	349.358	0.263420	0.614022
agreeableness	174.16	1	174.163	0.131321	0.721286
Conscientiousness	50.62	1	50.623	0.038171	0.847290
neuroticism	462.11	1	462.114	0.348440	0.562336
openness	79.20	1	79.201	0.059719	0.809705
Error	23872.27	18	1326.237		
CONDITION	439.36	2	219.681	0.247400	0.782145
CONDITION*extraversion	179.71	2	89.856	0.101194	0.904014
CONDITION*agreeableness	55.92	2	27.961	0.031489	0.969029
CONDITION*Conscientiousness	146.78	2	73.390	0.082650	0.920847
CONDITION*neuroticism	286.09	2	143.047	0.161096	0.851820
CONDITION*openness	237.62	2	118.812	0.133803	0.875195
Error	31966.52	36	887.959		
INTERVAL	99.43	8	12.428	0.626015	0.754934
INTERVAL*extraversion	115.16	8	14.395	0.725080	0.669146
INTERVAL*agreeableness	39.71	8	4.963	0.249996	0.980163
INTERVAL*Conscientiousness	52.51	8	6.564	0.330636	0.953055
INTERVAL*neuroticism	39.42	8	4.927	0.248183	0.980620
INTERVAL*openness	64.82	8	8.102	0.408109	0.914493
Error	2858.83	144	19.853		
CONDITION*INTERVAL	114.47	16	7.154	0.385431	0.985174
CONDITION*INTERVAL*extraversion	157.44	16	9.840	0.530095	0.930398
CONDITIO*INTERVAL*agreeableness	87.97	16	5.498	0.296202	0.996602
CONDITION*INTERVAL*Conscientiousness	60.68	16	3.792	0.204310	0.999662
CONDITION*INTERVAL*neuroticism	45.08	16	2.817	0.151777	0.999954
CONDITION*INTERVAL*openness	45.03	16	2.814	0.151610	0.999954
Error	5345.90	288	18.562		

Heart rate variability: LF power relative to (LF+HF)-Age

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 57.32917				
	SS	dF	MS	F	p
Intercept	2416.61	1	2416.612	0.735285	0.400023
Age	7910.96	1	7910.958	2.407009	0.134445
Error	75592.59	23	3286.634		
CONDITION	295.03	2	147.516	0.322447	0.725998
CONDITIO*Age	276.68	2	138.341	0.302393	0.740505
Error	21044.46	46	457.488		
INTERVAL	387.64	8	48.455	0.837059	0.571085
INTERVAL*Age	356.19	8	44.524	0.769145	0.630380
Error	10651.34	184	57.888		
CONDITION*INTERVAL	661.87	16	41.367	0.820562	0.662208
CONDITION*INTERVAL*Age	671.19	16	41.949	0.832113	0.648813
Error	18552.06	368	50.413		

Oculomotor: Pupil Diameter-Age

Effect	Repeated Measures Analysis of Variance (Copy of Eye Movements) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 4.475941				
	SS	dF	MS	F	p
Intercept	309.4277	1	309.4277	15.44509	0.000715
Age	27.6416	1	27.6416	1.37973	0.252705
Error	440.7492	22	20.0341		
CONDITION	1.8534	2	0.9267	0.75210	0.477339
CONDITION*Age	2.2670	2	1.1335	0.91993	0.406076
Error	54.2159	44	1.2322		
INTERVAL	0.0894	8	0.0112	0.16453	0.995139
INTERVAL*Age	0.0819	8	0.0102	0.15061	0.996429
Error	11.9588	176	0.0679		
CONDITION*INTERVAL	0.2055	16	0.0128	0.56589	0.908543

CONDITION*INTERVAL*Age	0.2233	16	0.0140	0.61497	0.871993
Error	7.9875	352	0.0227		

Oculomotor: Eye speeds

Effect	Repeated Measures Analysis of Variance (Copy of Eye Movements) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 32.99255				
	SS	dF	MS	F	p
Intercept	29445.17	1	29445.17	27.05093	0.000028
Error	25035.70	23	1088.51		
CONDITION	938.38	2	469.19	0.65986	0.521749
Error	32708.05	46	711.04		
INTERVAL	142.44	8	17.80	1.05744	0.394982
Error	3098.08	184	16.84		
CONDITION*INTERVAL	297.30	16	18.58	1.21382	0.254264
Error	5633.31	368	15.31		

Oculomotor: Eye speeds-Age

Effect	Repeated Measures Analysis of Variance (Copy of Eye Movements) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 33.08776				
	SS	dF	MS	F	p
Intercept	258.70	1	258.703	0.236302	0.631697
Age	950.10	1	950.103	0.867833	0.361667
Error	24085.60	22	1094.800		
CONDITION	704.87	2	352.435	0.486855	0.617827
CONDITION*Age	856.42	2	428.210	0.591531	0.557820
Error	31851.63	44	723.901		
INTERVAL	49.83	8	6.229	0.361339	0.939529
INTERVAL*Age	64.23	8	8.029	0.465782	0.878962
Error	3033.84	176	17.238		
CONDITION*INTERVAL	146.92	16	9.182	0.593181	0.889037
CONDITION*INTERVAL*Age	184.40	16	11.525	0.744513	0.747659
Error	5448.91	352	15.480		

Oculomotor: Eye speeds-Sex

Effect	Repeated Measures Analysis of Variance (Copy of Eye Movements) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 33.29087				
	SS	dF	MS	F	p
Intercept	27203.66	1	27203.66	24.54578	0.000059
Sex	653.50	1	653.50	0.58965	0.450720
Error	24382.21	22	1108.28		
CONDITION	681.00	2	340.50	0.47630	0.624240
CONDITION*Sex	1253.55	2	626.77	0.87676	0.423272
Error	31454.51	44	714.88		
INTERVAL	124.00	8	15.50	0.92998	0.493100
INTERVAL*Sex	164.78	8	20.60	1.23589	0.280675
Error	2933.29	176	16.67		
CONDITION*INTERVAL	272.37	16	17.02	1.09909	0.354058
CONDITION*INTERVAL*Sex	181.31	16	11.33	0.73161	0.761489
Error	5452.01	352	15.49		

Oculomotor: Fixation Duration-Personality

Effect	Repeated Measures Analysis of Variance (Copy of Eye Movements) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: .1231369				
	SS	dF	MS	F	p
Intercept	0.078616	1	0.078616	5.184838	0.035226
Extraversion	0.000733	1	0.000733	0.048345	0.828442
Agreeableness	0.000082	1	0.000082	0.005412	0.942165
Conscientiousness	0.004258	1	0.004258	0.280814	0.602644
Neuroticism	0.009309	1	0.009309	0.613915	0.443506
Openness	0.002465	1	0.002465	0.162565	0.691555
Error	0.272929	18	0.015163		
CONDITION	0.015001	2	0.007501	1.332649	0.276478
CONDITION*extraversion	0.003148	2	0.001574	0.279684	0.757650
CONDITION*agreeableness	0.000702	2	0.000351	0.062359	0.939647

CONDITION*Conscientiousness	0.015989	2	0.007995	1.420411	0.254832
CONDITION*neuroticism	0.010688	2	0.005344	0.949422	0.396440
CONDITION*openness	0.004951	2	0.002476	0.439845	0.647551
Error	0.202623	36	0.005628		
INTERVAL	0.000878	8	0.000110	1.290366	0.252956
INTERVAL*extraversion	0.000666	8	0.000083	0.978841	0.455001
INTERVAL*agreeableness	0.000392	8	0.000049	0.576033	0.796313
INTERVAL*Conscientiousness	0.000986	8	0.000123	1.449530	0.180954
INTERVAL*neuroticism	0.000453	8	0.000057	0.666420	0.720349
INTERVAL*openness	0.000751	8	0.000094	1.104478	0.363638
Error	0.012241	144	0.000085		
CONDITION*INTERVAL	0.001001	16	0.000063	0.834813	0.645458
CONDITION*INTERVAL*extraversion	0.000672	16	0.000042	0.560580	0.911529
CONDITION*INTERVAL*agreeableness	0.000655	16	0.000041	0.546241	0.920737
CONDITION*INTERVAL*Conscientiousness	0.001030	16	0.000064	0.859234	0.617095
CONDITION*INTERVAL*neuroticism	0.000498	16	0.000031	0.415611	0.978073
CONDITION*INTERVAL*openness	0.001062	16	0.000066	0.885957	0.585994
Error	0.021575	288	0.000075		

Oculomotor: Blink Frequency-Age

Effect	Repeated Measures Analysis of Variance (Copy of Eye Movements) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 21.60927				
	SS	dF	MS	F	p
Intercept	4565.640	1	4565.640	9.777354	0.005826
Age	1453.076	1	1453.076	3.111773	0.094693
Error	8405.292	18	466.961		
CONDITION	166.837	2	83.418	1.365007	0.268279
CONDITION*Age	187.036	2	93.518	1.530274	0.230226
Error	2200.033	36	61.112		
INTERVAL	21.513	8	2.689	0.560658	0.808623
INTERVAL*Age	18.556	8	2.320	0.483596	0.866328
Error	690.688	144	4.796		
CONDITION*INTERVAL	87.517	16	5.470	1.451685	0.117131

CONDITION*INTERVAL*Age	97.402	16	6.088	1.615658	0.063892
Error	1085.153	288	3.768		

Oculomotor: Blink Duration-Age

Effect	Repeated Measures Analysis of Variance (blink duration) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 140.6580				
	SS	dF	MS	F	p
Intercept	63978.3	1	63978.31	3.233729	0.088929
Age	4483.5	1	4483.48	0.226614	0.639773
Error	356124.4	18	19784.69		
CONDITION	4338.2	2	2169.09	0.901869	0.414782
CONDITION*Age	4974.2	2	2487.09	1.034089	0.365870
Error	86583.8	36	2405.10		
INTERVAL	2225.2	8	278.15	1.091185	0.372693
INTERVAL*Age	1854.5	8	231.81	0.909370	0.510596
Error	36707.1	144	254.91		
CONDITION*INTERVAL	3143.7	16	196.48	1.453501	0.116379
CONDITION*INTERVAL*Age	3008.8	16	188.05	1.391104	0.144660
Error	38931.8	288	135.18		

Perceived control-Age

Effect	Repeated Measures Analysis of Variance (Perceived control) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 1.110622				
	SS	dF	MS	F	p
Intercept	2.99055	1	2.990552	2.424480	0.133107
Age	0.50992	1	0.509919	0.413398	0.526609
Error	28.37008	23	1.233482		
CONDITION	0.44713	2	0.223567	0.393464	0.676964
CONDITION*Age	0.58276	2	0.291382	0.512815	0.602190
Error	26.13724	46	0.568201		

Perceived control-Sex

Effect	Repeated Measures Analysis of Variance (Perceived control) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 1.095445				
	SS	dF	MS	F	p
Intercept	832.3200	1	832.3200	693.6000	0.000000
Sex	1.2800	1	1.2800	1.0667	0.312438
Error	27.6000	23	1.2000		
CONDITION	1.6933	2	0.8467	1.4715	0.240177
CONDITION*Sex	0.2533	2	0.1267	0.2202	0.803238
Error	26.4667	46	0.5754		

Perceived control: personality trait

Effect	Repeated Measures Analysis of Variance (Heart Rate 5 minute intervals) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 59.19763				
	SS	dF	MS	F	p
Intercept	3725.01	1	3725.010	1.062964	0.315486
Extraversion	4451.66	1	4451.664	1.270321	0.273740
Agreeableness	219.99	1	219.993	0.062777	0.804849
Conscientiousness	5186.63	1	5186.625	1.480049	0.238664
Neuroticism	9711.11	1	9711.112	2.771151	0.112382
Openness	2424.00	1	2424.001	0.691710	0.415914
Error	66582.84	19	3504.360		
CONDITION	1117.82	2	558.910	1.435364	0.250642
CONDITION*extraversion	1514.96	2	757.481	1.945323	0.156915
CONDITION*agreeableness	1255.60	2	627.802	1.612289	0.212775
CONDITION*Conscientiousness	1001.60	2	500.801	1.286131	0.288093
CONDITION*neuroticism	1761.66	2	880.829	2.262099	0.117978
CONDITION*openness	451.23	2	225.613	0.579407	0.565102
Error	14796.65	38	389.386		
INTERVAL	262.17	8	32.771	0.581045	0.792363

INTERVAL*extraversion	464.25	8	58.032	1.028915	0.416771
INTERVAL*agreeableness	328.23	8	41.029	0.727453	0.667080
INTERVAL*Conscientiousness	268.45	8	33.556	0.594959	0.780973
INTERVAL*neuroticism	433.12	8	54.141	0.959928	0.469587
INTERVAL*openness	525.30	8	65.662	1.164209	0.324400
Error	8572.90	152	56.401		
CONDITION*INTERVAL	1003.59	16	62.724	1.219980	0.250938
CONDITION*INTERVAL*extraversion	741.88	16	46.368	0.901843	0.567507
CONDITION*INTERVAL*agreeableness	1117.14	16	69.821	1.358014	0.161322
CONDITION*INTERVAL*Conscientiousnes s	383.69	16	23.980	0.466414	0.961370
CONDITION*INTERVAL*neuroticism	948.70	16	59.294	1.153261	0.305363
CONDITION*INTERVAL*openness	613.24	16	38.327	0.745458	0.746281
Error	15629.93	304	51.414		

Subjective Measures: MDSI

Effect	Repeated Measures Analysis of Variance (driving performance) Sigma-restricted parameterization Effective hypothesis decomposition; Std. Error of Estimate: 6.559249				
	SS	dF	MS	F	p
Intercept	2.402	1	2.40214	0.055833	0.815876
MDSI	7.675	1	7.67530	0.178397	0.677757
Error	774.427	18	43.02375		
CONDITION	77.723	2	38.86165	0.838403	0.440668
CONDITION*MDSI	83.879	2	41.93946	0.904803	0.413624
Error	1668.673	36	46.35202		
INTERVAL	130.942	45	2.90983	0.714135	0.921100
INTERVAL*MDSI	153.124	45	3.40275	0.835109	0.771587
Error	3300.444	810	4.07462		
CONDITION*INTERVAL	268.171	90	2.97968	0.729812	0.972337
CONDITION*INTERVAL*MDSI	313.162	90	3.47958	0.852252	0.834704
Error	6614.143	1620	4.08280		