THE EFFECT OF THE TEMPO OF MUSIC ON CONCENTRATION IN A SIMULATED DRIVING EXPERIENCE

by

HENRIËTTE VENTER

submitted in accordance with the requirements for
the degree of

MASTER OF ARTS IN SOCIAL SCIENCE

in the subject of

PSYCHOLOGY

at the

UNIVERSITY OF SOUTH AFRICA

SUPERVISOR: Dr. H. C. Janeke

February 2011

ABSTRACT

Performing multiple tasks simultaneously is proposed to have an influence on the amount of mental resources available for attending to incoming stimuli's. Concentration is presumed to be divided between focussing on driving (incoming visual information) while attending to incoming auditory information. The study aimed to investigate the influence of the tempo of music on concentration and driving ability by means of simulation. Concentration was measured by driving errors (DE) whereas driving ability was measured by lap-times (LT) and elicited behaviour. Four treatment conditions were utilised; that is a no-music (NM) control condition, low tempo music (LTM)-, medium tempo music (MTM)- and high tempo music (HTM) treatment conditions. Results found that the tempo of music does not have an influence on concentration; however, significant results were obtained indicating that the tempo of music does have an influence on driving behaviour.

Key Terms:

Tempo of music; Concentration; Driving ability; Driving errors; Lap-time; No-music; Low tempo music; Medium tempo music; High tempo music.

DECLARATION

Student number: 4685-810-5

I declare that I declare that “The effect of the tempo of music on concentration in a simulated driving experience” is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

____________________ ____________________

SIGNATURE DATE

(Miss H. Venter)

ACKNOWLEDGEMENTS

First and foremost, my greatest offering of thanks, honour and praise is humbly extended to my Lord and Saviour Jesus Christ whose divine grace, guidance, faithfulness, strength and mercy have carried me through all my life. For this achievement I take no glory unto myself. *"For I can do everything through Christ, who gives me strength" Philippians 4:13.*

To my supervisor – Chris Janeke: Thank you for your support, guidance during this process, it has been of great value to me and I would not have been able to finish this project without your expertise and valuable contributions.

To my family – my Dad JC and Mom Rinette, Coenette, Pieter and Monique: Thank you for your patience, prayers, love and undying support throughout this journey and my entire life. It's been a long road and I thank you for believing in me right from the start, for supporting me in my decisions and encouraging me to never give up; especially in times when I didn't think I would make it. You always had words of encouragement and I would not have been able to have come this far if it was not for all of you. I love you more than words can say!

And last but definitely not least, to my dearest Jurgie – to you I say a big thank you for being there to listen, comfort, support and encourage me in everything I do. Your guidance in planning the study and contributions have been invaluable to me. Thank you for being such a significant part of my life, I cannot imagine my life without you. You are my rock on who I can depend, ALWAYS, and I thank you for this!

LIST OF ABBREVIATIONS

ARAS	Ascending reticular activating system
BPM	Beats per minute
dB	Decibel
DE	Driving errors
EEG	Electroencephalogram
EEG signals	Electrophysiological signals
fMRI	Functional Magnetic Resonance Imaging
HTM	High tempo music treatment condition
H1	Hypothesis 1
H2	Hypothesis 2
H3	Hypothesis 3
IOR	Inhibition of Return
LT	Lap-times
LTM	Low tempo music treatment condition
MEG	Magnetoencephalography
MTM	Medium tempo music treatment condition
NM	No-music control condition
PET	Positron Emission Tomography
RAS	Reticular Activating System
TTS	Temporary Threshold Shift

TABLE OF CONTENTS

CHAPTER 1:

INTRODUCTION

1.1 PROBLEM STATEMENT AND JUSTIFICATION

1.1.1 Identifying the existence and importance of an under-investigated relationship between music and concentration

Have you ever found that you turn the volume of the music down while you are driving in situations which require concentration? When presented with this question, people usually respond with a “yes”. On the popular worldwide social network *Facebook*, a group has been established, under the title “Lowering the music when looking for a street address so I can see better”. The group has already been joined in August of 2010 by 928,280 individuals (Facebook, 2010). From the comments placed on this group’s homepage, it appears that many individuals have shared the same experience and tacitly acknowledge the existence of a relationship between music and human concentration. The proliferation of comments indicating an interest in finding out why this occurs suggests that many people do not fully understand why this phenomenon takes place. The aim of this dissertation is thus to explore some aspects of the relationship between music and driving a motor vehicle, and, hopefully, shed some light on the issue.

1.1.2 Investigating the existing literature indicating a possible existence of the proposed relationship

Brodsky (2002, p. 219) says that "the automobile is currently the most popular and frequently reported location for listening to music" while Agnew, Darrow, Johnson and Rink (2004) state that music is an "associative task", which implies that people conduct their activities while listening to music. For this reason it is important to analyse the influence of music on the concentration and driving ability of individuals. Beh and Hirst (1999) state that because most people drive with loud music playing, it would be interesting to find out if the driving task itself is influenced by this factor.

A study by Dibben and Williamson (2007) indicates that drivers turn the volume of their music up or down depending upon the situation they are in. Individuals thus appear to regulate their exposure to music; this regulation illustrates an implicit acceptance that music may affect their ability to drive. It can be postulated from the above that the volume of the music will not be turned down if an individual does not find it distracting.

1.1.3 Other factors pertaining to the possible decrease in concentration while driving

Other factors that influence concentration while driving are widely known, and these include the use of alcohol, drugs, mobile phones and also fatigue. Research conducted on the use of mobile phones while driving has indicated that reaction time may decrease (Berg, Consiglio, Driscoll & Witte, 2003); reaction time is the time it takes an individual to respond to factors around him/her. Johnston and Strayer

(2001) found in their study of mobile phone use during driving that driving performance is negatively affected because one's attention is divided. Bellinger, Berg, Budde, Machida and Richardson (2009) conducted a study to determine reaction- and movement-time. This measured the brake responses of a person making use of a cellular phone while driving as well as listening to music while driving. The results indicate that reaction time decreases when a person uses their mobile phone, whereas movement time appears to increase under the same circumstances.

Past research regarding alcohol's influence on driving claimed that alcohol consumption increases the risk of motor-vehicle accidents (French, Irving, Kemp, West & Wilding, 2006). In a study conducted by these researchers which investigates the effect of alcohol on hazard-perception and driving speed, it was found that with a moderate amount of alcohol having been consumed, the time it takes a person to respond to hazards increases, however, speed did not seem to be affected. The general conclusion drawn by French et al. (2006) is that alcohol contributes to an increase in response time when responding to traffic hazards. Another study investigating the effect of alcohol on driving ability found that the following-distance maintained behind another motor vehicle is less when alcohol has been ingested as opposed to if it is not. The same study concluded that steering ability decreases and the occurrence of moving out of the lane increase significantly when alcohol has been consumed (Baker et al., 2000).

1.1.4 Tempo of music as the primary source of investigation

Although the abovementioned issues are widely known and a large body of research has been conducted on them, the study reported in this dissertation explores activities that people engage in while driving and focuses specifically on the effect that music's tempo has on concentration. Note, that 'concentration' is also referred to as attention (Galotti, 2004), so that in this dissertation these terms are used interchangeably.

According to Galotti (2004, p. 579), *attention* entails "cognitive resources, mental effort, or concentration devoted to a cognitive process". Attention is also referred to as the "capacity for sustaining attention to a particular stimulus or activity" as defined by Shaffer (2002, p. G-1). Attention, on a more personal level, is defined as that which a person focuses on which requires cognitive resources and mental effort. This is exerted in order to complete a task or activity successfully (i.e. to the individual's best ability), without allowing too many other factors to influence and distract their attention.

Focused attention is a more directed form of attention and entails "the ability to respond and pick out the important elements of 'figure' of attention from the 'ground' or background of external and internal stimulation" (Culbertson, Spiers & Zillmer, 2008, p. 241). *Divided attention* requires attention to be focused on numerous incoming stimuli at any given moment as opposed to moving back and forth from different stimuli as is the case with alternating attention. *Sustained attention* is indicative of a sustained level of vigilance and the maintenance of that level of focus.

According to Culbertson et al., it is the “ability to maintain an effortful response over time” (2008, p. 241).

There are multiple elements contained in music which can be considered a distraction while driving; these include frequency, volume, vocals and instruments. The focus of this study however, will be purely on tempo. It was proposed by Bauer (2009) that any system requiring input while driving can act as a source of distraction. Thus the aim of this study is to determine whether the tempo of music indeed has an influence on concentration and driving ability. The study proposes an examination of the effect of musical tempo on concentration. Furthermore, the effects that different tempos have on concentration and driving ability are also explored; thus, the difference between the effects of having no music playing, and the effects of low-, medium- and high-tempo music are each investigated.

The general issue of the tempo of music and its influence on concentration is approached systematically. This implies that the results obtained will provide an indication as to whether or not tempo is a factor contributing to the decrease in concentration while driving. If this is found to be true, other elements of music could also be investigated in order to determine whether they too are additional impediments to a driver’s concentration. If this is not the case however, they could be disregarded and other musical elements could be investigated. These elements include volume, intensity, vocals and instruments.

1.1.5 Could in-vehicle music-listening contribute to traffic accidents?

This speculation is difficult to confirm as there are no formal government-issued statistics available which detail a relationship between the effects of listening to music while driving and motor-vehicle accidents in South Africa. Brodsky (2002) conducted a study investigating the effects of musical tempo on simulated driving performance and vehicular control with a sample of twenty music students. Tempo was one of the points of investigation in the study as it had not featured in any existing research; tempo was therefore investigated for its possible impairment of a driver's speed estimation. It was hypothesised that computer simulated driving in the presence of fast paced music (120 BPM and above) at a volume of approximately 85dB leads to an increased heart rate, a decrease in lap-times and an increase in errors (Brodsky, 2002).

Brodsky (2002) however, found no statistical evidence regarding music-related vehicle accidents. It would seem therefore, that this is not yet a factor that the members of the general public recognise as a risk to their safety. As the aim of this study is to prove that music has an effect on one's ability to drive, it is vital to raise the public's awareness of this fact. Thus this study also aims to educate the public about the risks involved in listening to music while driving (Brodsky 2002).

Readily available statistics regarding general motor-vehicle accidents indicate that South Africa is estimated to have one of the highest number of road-accident fatalities in the world. There are approximately 10,000 fatal car accidents each year, and out of every 100,000 people involved in accidents, approximately 23 are killed.

Furthermore, from a total of 500,000 motor-vehicle accidents per year, it was found that approximately 40,000 people sustained serious injuries while 110,000 suffered only minor injuries (Car-accidents.com, 2008). The statistics however, do not reveal the underlying causes of these accidents and therefore do not address the specific issue of listening to music in a vehicle as a contributory factor. Hence it is extremely difficult, if not impossible, to determine the effect that music has on driving ability simply because there is no existing method of investigation that can prove the phenomenon.

1.1.6 Postulated reasons for motor-vehicle accidents

Lagarde (2007) attempted to provide some insight into the concept of Road Traffic Injury (RTI) but stated that research relating to RTI within Africa is limited. The severity of motor-vehicle accidents in Africa is estimated to be significantly higher than anywhere else, based on the vast number of road users involved. This is believed to be due to a lack of seatbelts, the overcrowding of vehicles and the hazardous nature of many of the vehicles (Lagarde, 2007). Another factor worthy of consideration is that of the poor road conditions which also contribute to vast number of motor-vehicle accidents not only in Africa, but also in South Africa. In Africa it has been estimated that approximately 144,000 people will die due to road traffic accidents in 2020, which indicates a 144% increase from the 59,000 people who died in 1999 (Cropper & Kopits, 2005).

1.2 MOTIVATION FOR THE STUDY

1.2.1 An identified gap in existing research conducted on the subject matter

According to Beh and Hirst (1999), research regarding the effect of music while driving dates back to the 1970s but is limited as this existing research has indicated different outcomes in relation to the effects of music on a driver's concentration. This lack of a body of research findings points to a gap in this field of psychology. This is the main reason why an attempt is made in this study to explore some aspects of the relationship between music and driving a motor vehicle.

Brodsky (2002) states that there is not enough information and evidence to determine what effect music has on a person's driving performance. Beh and Hirst (1999) point out that little attention has been given to the possibility that music could be an element of noise which can influence driving performance. Hargreaves and North (2008, p. 125) state that "it is clear that aspects of the music, listener, and listening situation interact with one another continually in any particular instance of musical preference". Minimal research exists which investigates the relationship between musical preference and emotional response; this is possibly because the phenomenon is abstract and extremely difficult to study (Hargreaves and North, 2008).

Boyle and Radocy (2003) state that behaviour and cognitive perception are an integrated function and concept which are mutually interdependent on each other. They continue by saying that many professionals in the field of psychology and education demonstrate an increasing interest in understanding the effect of musical rhythm on people's behaviour and their interaction with that rhythm.

1.3 RESEARCH QUESTIONS AND HYPOTHESIS

Does the tempo of music cause a decrease in concentration while driving, and in turn influence driving ability? In order to determine whether this is true it is hypothesised (H1) that the tempo of music does influence concentration while driving. It is also hypothesised (H2) that high tempo music (HTM) causes a larger decrease in the amount of concentration when driving as opposed to low tempo music (LTM) and medium tempo music (MTM). Finally, it is hypothesised (H3) that the tempo of music does influence driving behaviour.

Thus, the aim of the study is to investigate the amount of driving errors (DE) made in the presence of the NM control condition and the LTM, MTM or HTM treatment conditions. An investigation will be conducted to determine whether the tempo of music indeed exerts an influence on concentration. Concentration in this regard refers to the amount of attentional resources available with which a driver can focus on the road ahead, without being too distracted by auditory stimulation that consumes all of the available resources of this kind.

1.4 OUTLINE OF CHAPTERS

The study presented in this document is subdivided into five chapters. Chapter One presents a broad overview and general introduction to the research problem identified and the motivation for undertaking the study. A gap is identified pertaining to the amount of research conducted regarding music and its effect on driving. Supporting literature which discusses previous studies and their findings is presented. Alternative influences on concentration such as alcohol and mobile phone use while driving are mentioned as having a detrimental effect, although these two factors are not the main focus of this investigation. It is indicated that this study focuses solely on the tempo of music and it is speculated whether music can act as a cause of motor-vehicle accidents. Results pertaining to this did not find conclusive evidence.

Chapter Two provides a thorough investigation of the existing literature related to the main topic. The concept of attention and the related theories and models of attention are discussed in detail. In the context of this study the term concentration is used, however, existing literature and theory more often refer to this as attention. As previously mentioned, depending on the context both terms are deemed to have the same meaning. Definitions of concentration are given and explained and these include the concept's relevance to the study and how it contributes to the phenomenon under investigation. An exploration of the neurophysics and cognition of music perception and three different contexts of music and their influence is then presented; these contexts include: music as a negative influence on concentration; music as a positive influence in this respect; and music as having no influence on concentration.

Thereafter, neural processes and brain-region functioning are described in order to determine whether there is an overlap in neural modalities; this section looks specifically at visual and auditory neural processes. The reason for this is to determine whether any of these sensory modalities specified above results in an interference on one another which in turn, could lead to a decrease in the amount of attentional resources available. If this is found to be true, it could be said that the two sensory modalities have a reciprocal effect on one another, which is detrimental to one's driving ability. Furthermore, attention is also a point of discussion with regard to the biological structure of the brain and its functioning, just as it is the case with visual and auditory information.

Musical preference is considered to have an influence on individual performance and is therefore also discussed. Emotional responses to music are also considered and discussed, followed by music serving a background purpose and, the volume of music and the health risks associated with volume.

Chapter Three presents the reader with an overview of the methodology and the research design employed. Included in this chapter is a description of the sample and the shortcomings and strengths of the research design. Furthermore the research instruments and the practical applicability of the study are described. The reliability and validity of these instruments are considered and discussed in detail. Thereafter, the procedure for obtaining the data is given and this is followed by a discussion of the ethical issues related to the study.

Chapter Four gives a statistical analysis based on the results obtained in the experiments while Chapter Five presents an in-depth discussion of the findings of Chapter Four. Thus, a summary of the general findings and the practical implications of the findings are provided in this chapter. The appendices present the reader with exemplars of the consent form, the questionnaire completed before the commencement of the study and a copy of the scoring sheet used to observe behaviour and record lap times and deviations.

CHAPTER 2:

THEORETICAL FRAMEWORK & LITERATURE REVIEW

2.1 INTRODUCTION

In this study the terms ‘concentration’ and ‘human attention’ are both utilised. Both refer to the same general cognitive process involving sustained or focused attention and thus they are used interchangeably. Throughout this document the main theme of investigation is concentration and therefore the exact nature of human attention and how it relates to music and music’s influence on it are discussed.

The theory assumed to be the basis for the understanding of music and its influence on concentration and driving ability comes from the field of cognitive psychology. Throughout this chapter, literature from the said field will be used to help investigate how the tempo of music influences human attention.

2.2 WHAT IS CONCENTRATION?

Concentration is a very ambiguous term and defining it is extremely difficult. According to Galotti (2004, p. 86), driving involves more factors than just braking, steering and shifting gears. There are also many cognitive processes involved, of which perception is one. This includes recognising objects such as other motor vehicles, pedestrians and road signs. Galotti (2004) uses the term attention to refer to concentration and points out that the amount of concentration needed during a given situation will be determined by the complexity of one’s surroundings. Attention is used interchangeably in this document. Attention is utilised in terms of theoretical discussion whereas the concentration is referred to when discussing the study under investigation.

Selective attention refers to the situation in which the focus of attention is divided between several tasks at once (Galotti, 2004). In general terms the lay person might refer to this concept as multi-tasking. What people may not know however, is that on top of the many tasks that he/she is aware of, are many unconscious tasks (Galotti, 2004). An individual may think that he/she is aware of all surrounding elements while driving, but due to limited attentional resources, some of these elements are not processed consciously. This could be illustrated in something as simple as not being aware of another motor vehicle that comes to a standstill, simply because attentional resources are directed somewhere else. More specifically, Galotti (2004, p. 89) refers to some tasks as being “shut out” from awareness. On the other hand, some tasks may not be completely shut out, but just less attended to. This implies that there is not as much information extracted from certain tasks in comparison to others; these tasks could be anything in one’s surrounding contexts in which one stimulus takes precedence over another.

Galotti (2004) states that individuals possess a limited amount of mental resources that are available to each task and all incoming information. When resources are employed in one task, there are fewer resources available for other simultaneous tasks. These facts validate the assumption that music could possibly exert a negative influence on concentration. Thus, when focusing on the task of driving it is postulated that there are limited resources available for the processing of auditory information.

Conversely, if attention is given to auditory information, it is postulated that there are fewer mental resources available for the processing of visual information. If attention is therefore not primarily focused on the task of driving, this may result in detrimental consequences.

2.3 THEORIES OF ATTENTION

The *executive control process* refers to the ability to regulate attention, after which one must be able to adequately determine what one has to do with that information. *Span of apprehension* is defined as the amount of information that can be referred to at a single point in time without the need for mental operation to store that information. *Strategies* refer to the focused mental operations that are utilised to facilitate the performance related to a specific task (Shaffer, 2002). All of these concepts are related to and postulated to be an integral part of the concentration exerted while driving.

Models of attention, as discussed in Culbertson et al. (2008), include Mesulam's Model of Spatial Attention, Posner's Anterior and Posterior Attention Model, and Mirsky's Elements of Attention Model.

2.3.1 Mesulam's Model of Spatial Attention

Mesulam's Model of Spatial Attention postulates that the *frontal*, *parietal* and *cingulated cortex* form part of a neural network that supports spatial attention to the outside world (Mesulam, 2000). These regions together with other subcortical regions situated in the *thalamus* and *striatum* are able to initiate spatial attention. Individually however, each region performs a different function in which the parietal region is responsible for internalising external stimuli; this is done through the creation of a sensory map. The *cingulated cortex*, on the other hand, functions to maintain the emotional and interpersonal importance of incoming stimuli from the external environment. The *frontal cortex* is responsible for conducting motor functioning which is used for exploring and scanning the external environment, fixation and manipulation (Mesulam, 2000).

Fixation implies the focusing of attention on an external element (Atkinson & Hood, 2007); “This model thus conceptualises spatial attention in terms of sensory representation, motivational importance and expectancy, and motor response” (Culbertson et al., 2008, p. 243).

To summarise, Mesulam’s model of attention assumes that the organs employed in the focusing of attention are the sensory organs. Anticipation for a certain event to occur can therefore result in an increase or decrease of attention and motor response. Therefore, music that is perceived by the auditory neural network will affect spatial attention which is perceived by means of the visual neural network. It is thus assumed that a lack of visual neural network resources, which is the result of music using mental resources, will influence motor responses when an event occurs. Thus the ability to anticipate the occurrence of another event will be decreased.

2.3.2 Posner's Anterior and Posterior Attention Model

Michael Posner states that attention can be classified by three functions: orientation with the external world, the ability to be vigilant or alert, and conducting voluntary actions (Fernandez-Duque & Posner, 2001).

All neural networks function interactively with each other and with other cortical and subcortical regions. Separate neural networks support attention; these networks are orienting, vigilance and executive networks (Culbertson et al., 2008).

When focusing on stimuli in the external visual environment, three mental processes are occurring: to *disengage*, to *shift* and to *engage* (or activate) attention. These three processes are coordinated by the *parietal*, *midbrain* and *thalamic regions*. That which is focused on in the external visual environment is eventually disengaged from, after which focus is shifted to a new external stimulus and then focus is re-engaged on that new stimulus (Culbertson et al., 2008). This is referred to as the *visual orienting system*, or more formally, the posterior attention system (Culbertson et al., 2008).

Based on the Posner model, Atkinson and Hood (1997) go on to explain that if attention moves back to the point at which it was disengaged in the first place, or to a new location, the processing of other stimuli is inhibited in comparison to stimuli identified at other spatial locations. This is referred to as the *inhibition of return* (IOR). IOR is further explained thus: stimuli that have already been focused on and processed will not be the point of attraction again as the focus would rather shift to a new and unfamiliar location where new stimuli can be processed. The rate at which attention is shifted changes and increases with age, thus moving from a subcortical to a cortical form of information processing (Atkinson & Hood, 1997).

The posterior attention system is involved in conscious attention; that is when attention is directed towards a certain point in one's visual space. Regions involved include the *posterior parietal lobe*, the *midbrain superior colliculus* and the *pulvinar* of the *thalamus*. The latter involves the selection and filtering of relevant information for the purpose of processing information. The posterior parietal lobe's function is to direct attention to specific spatial targets and the midbrain superior colliculus is responsible for the movement of the eyes from one point to another. *Overt orientation* refers to attention being focused on an object in one's visual spatial field without moving one's head or eyes (Culbertson et al., 2008). The single region of the brain that is a vital part in the focusing of attention is the *thalamus*; it is responsible for making the distinction between that which is relevant to processing and that which can be disregarded.

The *vigilance attention system* involves alertness, particularly with regard to processing information that is high in priority. This implies that all factors that are less relevant will be ignored in order to avoid distraction; this happens regardless of whether these factors are internal or external in nature. The neural network operating in the vigilance attention system includes the right frontal and parietal regions. *Norepinephrine* is the neurotransmitter that allows a state of alertness to be maintained over a period of time; this is crucial for the maintenance of attention (Culbertson et al., 2008).

The *anterior* and *executive attention systems* are responsible for voluntary attention. The *executive attention system* also controls other cognitive functions which include task switching, inhibition control, conflict resolution, error detection, attention-resource allocation, and the planning and controlling of novel stimuli. Other cortical and sub-cortical regions involved in the executive attention system are the *anterior cingulate* and the *lateral prefrontal cortex* (DiGirolamo & Posner, 1998). The former is responsible for controlling conflict resolution between different brain regions. The latter is responsible for temporarily maintaining the mental representations of certain incoming information (Fan & Posner, 2004). Unlike norepinephrine, which is responsible for alertness in the vigilance attention system, *dopamine* is a neurotransmitter responsible for activating the anterior and executive attention systems (Fernandez-Duque & Posner, 2001).

2.3.3 Mirsky's Elements of Attention Model

Allen Mirsky identifies four important elements of attention: *focus-execute attention*, *shifting attention*, *sustained attention* and *encode attention* (Mirsky, 1996). Investigating each of these respectively as described by Culbertson et al. (2008), it can be said that focus-execute attention is involved with selective attention and perceptual-motor output. Shifting attention refers to the moving of attention from one point of focus to another. Sustained attention refers to vigilance while encoding implies the ability to hold information in memory while doing other tasks simultaneously (Culbertson et al., 2008). A fifth element has been identified: it is known as *stable attention* which refers to the consistency of one's attention.

In general it appears as though these three theorists have reached a consensus regarding some of the brain structures and neural networks that work together. According to this conceptualisation of the attentional system, it consists of both cortical and subcortical structures. In the cortical regions the areas involved are the parietal and frontal lobes. The subcortical regions are the anterior cingulate, the thalamus, colliculus and basal ganglia (Culbertson et al., 2008). Also, despite labelling them differently, both Posner's and Mirsky's models of attention describe a similar process of disengaging focus from one stimulus and refocusing it on a new stimulus.

2.3.4 Other theories and models of attention

Other factors pertaining to theories of attention reviewed by Galotti (2004) include selective attention. This consists of numerous factors and thus various models have been proposed to account for this. These include *filter theory*, *attenuation theory*, *late-selection theory*, *multimode theory*, *attention, capacity and mental effort theory*, and *schema theory*.

2.3.4.1 Filter theory

Filter theory was developed by Broadbent (1958) and is referred to by Galotti (2004) as the restricted amount of information to which any one person can pay attention at any given time. If this limited capacity is reached, the attentional filter can only process some information and blocks out the rest.

With regard to the filter theory, it is said by Galotti (2004) that only two different types of messages which contain a small amount of information can be processed and attended to at the same time. Thus, if two messages contain complex stimuli's, less incoming information can be attended to at once (Galotti, 2004). Filter theory is assumed to protect us from an "information overload by shutting out messages when we hear too much information all at once" (Galotti, 2004, p. 92). This confirms H1 and H2 by providing evidence which supports the concept that a limited amount of mental resources can be allocated to tasks. Thus, if the task of driving is classified as being complex, the chances are that only one perceived stimulus (either visual or auditory) will be processed. If auditory information is processed it could have a detrimental effect on an individual's concentration while driving. This could however, be ascribed to the novelty effect which commonly affects novice drivers; it states that he/she is more susceptible to influence from external factors such as the presence of music.

2.3.4.2 Attenuation theory

Also discussed by Galotti (2004) is attenuation theory which was developed by Treisman (1960). This theory asserts that some of the meaningful information that is situated in unattended messages is still available for use. Incoming messages are processed in three different phases. These phases work as follows: in the first phase, the physical properties of the incoming message (loudness and pitch) are processed; in the next phase (the linguistics phase) the incoming message is broken up into its individual syllables and words in order to be processed; and finally, the semantic meaning of the message is processed (Galotti, 2004).

2.3.4.3 Late-selection theory

Late-selection theory; developed by Deutsch and Deutsch (1963) and later elaborated on by Norman (1968), claims that all incoming messages are processed and that some meaning is extracted from each message. The analogy of a bottleneck is used to explain late-selection theory; thus, all of the information is perceived but only the most important messages are processed further (Galotti, 2004). The messages that are processed further are more likely to be retained while unattended messages are usually discarded. The importance of a message is determined by numerous factors which include the context and the personal significance of the content of that message. The level of alertness also determines the type of information that is processed; thus a person's attentional system also has an influence in determining the importance of the messages to be processed (Galotti, 2004).

2.3.4.4 Multimode theory

Heinz and Johnston (1978) propose a multimode theory which incorporates both filter theory and late-selection theory. According to this theory, attention is regarded as flexible; consequently, this influences the selection of one message over another. Three stages are used to describe this process: in the first stage the sensory representations are constructed; the second stage attaches meaning to these representations; and during the third stage the sensory and semantic constructs are brought into consciousness. It is said that if more processing is required, more resources need to be available and thus that more mental effort is required (Galotti, 2004).

2.3.4.5 Attention, capacity and mental effort

Kahneman (1973) views attention as categorised, and as recognising stimuli by a set of cognitive processes. Attention can be focused on numerous tasks at once however, the quantity of attention required from each task will be the determining factor. Kahneman (1973) presents a model in which he allocates certain mental resources to cognitive tasks. The more complex the presented stimulus is, the more difficult it is to process. This leads to a decrease in the amount of cognitive resources available for other competing stimuli. Kahneman (1973) states that people do have the ability to make conscious decisions as to which stimuli they want to focus on, and thus cannot choose what to focus their mental effort on.

The abovementioned phenomena can be related to divided attention; this in turn refers to dual-task performance in which people are able both to alternate their attention between two tasks, and also allow a task to become automatic (Galotti, 2004). When a task becomes automatic it does not interfere with any other task being performed, and thus it does not make use of mental resources or effort (Galotti, 2004). Another explanation stated in Galotti (2004) is that people may have learned to perform and complete two tasks simultaneously.

According to Galotti (2004, p. 100) this could be illustrated as follows;

> "[T]he individual deposits mental capacity to one or more of several different tasks. Many factors influence this allocation of capacity, which itself depends on the capacity and type of mental resources available. The availability of mental resources, in turn, is affected by the overall level of arousal, or state of alertness."

Here it is implied that the result of alertness is an increase of available resources which can then be allocated to various tasks (Kahneman, 1973). However, it was acknowledged that the difficulty of a task influences the level of alertness. It is therefore implied that alertness has an influence on capacity, which is the amount of mental resources available for processing incoming information. This concept of alertness or arousal described by Kahneman (1973) is similar to that which is described by Berlyne (1971).

Some factors that may influence attention include the time of day and the total hours of sleep obtained the night before. All of these factors have an influence on the amount of tasks one is able to focus on, and according to Galotti (2004), they determine the amount of available attentional resources.

2.3.4.6 Schema theory

Schema theory states that unattended messages are not processed at all and thus they are not included in cognitive processing (Galotti, 2004). The total amount of sleep acquired is taken into consideration in this study as each participant was informed well in advance that they should obtain a good night's rest.

2.4 THE NEUROPHYSICS AND COGNITION OF MUSIC PERCEPTION

Research pertaining to the neuroscientific understanding of music perception has increased, as reflected in the amount of research that have been conducted over the last two decades. Grahn (2009) and Sloboda (2005) both point out that there was no scientific evidence available for the discipline of music psychology until approximately ten years ago.

The research area focusing on the relationship between music cognition and perception includes the understanding of the perception and comprehension of music, as well as memory, attention and performance (Wikipedia, 2010). In this context, perception and comprehension refer to the cognitive processing of music in the human brain. Memory, attention and performance are discussed in relation to existing research which sought to understand whether music has a negative or positive effect on concentration, or no effect at all. Numerous elements within music, such as volume, pitch, duration, tempo and intensity, contribute to its perception.

A measure to determine the regions within the human brain and the associated temporal relationships at play when performing tasks is referred to as *temporal localization*. When this approach, which measures brain activity, is employed, it provides a good indicator for the investigation of music and rhythm. *Music cognition* (Day, 2004) entails the understanding and comprehension of both physiological and psychological mechanisms that create a musical experience.

Grahn (2009, p. 257) defines *rhythm* as a "pattern of temporal intervals in a stimulus sequence". Rhythm is a "perceived pattern of events in time" (MIT Open Courseware, 2009, p. 3). Patel (2008) defined rhythm is as a repeated pattern occurring regularly and implies periodicity. It is however acknowledged that no universal definition, as to what rhythm entails, exists. For this reason he proposes the following definition: a "systematic patterning of sound in terms of timing, ascent, and grouping" (Patel, 2008, p. 96).

2.4.1 Investigating the perception of music in the human brain

Rhythm is said to provide the experience of a pulse, also known as a beat. Furthermore, rhythm is a stimulus which may be identified as a tone, click or sound (Grahn, 2009). Rhythm in music allows for synchronised periodic movements exhibited by taps or footfalls. In western culture, the rhythm of music alternates between beats of different strength; thus a rhythm hierarchy exists which relies on different beat strengths (Selkirk, 1984). Some functions associated with beat coordinate and determine synchronized movements, this is evident in dancing for instance (Patel, 2008).

Grahn states that "Cognitive neuroscience combines the experimental strategies and paradigms of cognitive psychology with neuroscientific techniques to examine how brain function supports mental processes" (2009, p. 252). Grahn (2009) mentions that several techniques can be used to measure the perception of music by employing neuroimaging methods, but he does not describe in detail all of the measures utilised. He does, however, provide some details about the application of these techniques with regard to tempo and human perception of music. Some of these techniques include the use of electrophysiological signals (EEG signals), Magnetoencephalography (MEG) and Hemodynamic methods which include fMRI and PET scans (Grahn, 2009).

When these techniques were applied to investigate rhythm perception in the human brain, it was found in fMRI studies that the *premotor cortex*, *supplementary motor cortex*, *cerebellum* and *basal ganglia* are involved in rhythm perception. The basal ganglia are said to ‘feel the beat’ (Grahn, 2009, p. 260). Another finding was that perception of rhythm requires an interaction between the auditory system and the motor system (Grahn, 2009).

Specifically referring to the neuroscience of music perception, the *“sensory-motor interactions”* as described by Chen, Penhune and Zatorre (2007) are of particular interest. Music is said to place demands on the nervous system, thereby aiding the explanation of neural functioning with regard to music. The perception of rhythm as an element contained in music is said to be dependent on the to and fro interaction of both the auditory and motor systems (Chen et al., 2007). This could refer to the eliciting of behaviour (body movements) by music.

Auditory-motor interactions are defined as “any engagement of or communication between the two systems, and may be conceptualised into two categories: “feedforward” and “feedback” (Chen et al., 2007, p. 550). The former describes the influence on the motor output from the auditory system (Large & Palmer, 2002). An example of this presented by Chen et al. (2007) is the tapping of one’s feet to the beat of music. This form of feedback is more relevant to the relationship between the tempo of music and driver concentration that is under investigation. Feedback models refer to the playing of an instrument in which all of the elements of the music should be controlled. The tapping of the foot in accordance with the beat indicates the ability to identify the repeating pulse central to various types of music (Chen et al., 2007). The explanation of this is that one has to be able to acquire complex temporal information from a perceived auditory stimulus which will allow one to elicit the appropriate movement at exactly the right time (Chen et al., 2007).

2.4.2 Music as a negative influence on concentration

Dibben and Williamson (2007) argue that distraction can be caused by numerous factors. Fundamentally, distraction takes place when a person's attention is shifted from the task at hand; in the context of this study it is the shifting of attention away from the task of driving, such as changing the radio station on the car stereo system. Driving requires cognitive, sensory and motor skills so that any other external stimulus could influence this process and have a negative consequence. It could thus influence factors such as positioning on the road, control over and maintenance of speed, reaction time and estimation time and decision-making (Dibben and Williamson, 2007).

In-vehicle music listening could have a detrimental effect on concentration especially when two tasks are performed simultaneously, but do not overlap in sensory and response modalities (Boer, Levy & Pashler, 2006). These statements by Boer et al. (2006) are in agreement with Galotti (2004) who points out the limited amount of information that an individual is able to attend to and process at the same time. When combining the claims of Galotti (2004) and Boer et al. (2006), it could be assumed that attentional resources are limited by performing two tasks simultaneously. This in turn is assumed to have an influence on the amount of attentional resources available, especially if the tasks are complex in nature.

Beh & Hirst explain that the effect that music has on a person greatly depends on the characteristics of the task at hand. This implies that tasks that require low cognitive capacity are not influenced by high intensity music as it does not interfere with the performance of these tasks (1999). However, these authors also state that when a task makes a high demand on cognitive resources, high intensity music does affect performance (Beh & Hirst, 1999). In a normal driving context this could mean that music could have either no effect or a detrimental effect on concentration and driving ability, with this depending on whether the individual experiences driving as a simple or a complex task.

Kiger (1989) states that music which is regarded as high intensity competes for attentional resources, and thus it interferes with the task of processing information. Although the task referred to here is reading comprehension, the concept is assumed to remain applicable to driving. Other earlier findings from the study by Konečni and Sargent-Pollock (1976) have similar results; high intensity and arousing music demands more attentional resources for processing than low intensity music. Konečni and Sargent-Pollock (1976) also state that music should be used selectively; one should only play music in situations that are regarded as simple. Music should not be played during the completion of complex tasks.

Hargreaves and North (2008) say that in high intensity traffic situations, music moderates situational arousal because a driving situation is regarded as having no specific arousal-based goal. The example of a clubbing context is used; it is proposed that the arousal-based goal is to achieve a party atmosphere and that in order to achieve a high arousal, arousing and stimulating music is required. Conversely, we tend to seek more mellow music when going to bed as it has a calming effect. Thus, a low-arousal goal is sought.

The implication of the above theory in the context of this study is that high arousal-based music is the cause of excitatory behaviour which causes a decrease in attention. Excitatory behaviour is proposed to decrease the attentional resources available to incoming stimuli perceived from other senses. This is due to the amount of resources that are employed in order to process the excitatory stimuli.

In an article obtained from Beeld (2010), existing research suggests that listening to loud music influences the speed at which a person is able to make decisions; the risk of missing a red traffic light is thus increased. The article also states that listening to the right music helps to prevent accidents. As opposed to general assumptions, classical music is not the optimal choice as it is suggested to cause drowsiness. The types of music which are suggested to be beneficial for good driving performance are those consisting of a good beat and those regarded as good sing-along songs. The volume and tempo of these should however, be taken into account and not be too loud. Also, if music contains more than 60 beats per second heartbeat and blood pressure are increased.

A study conducted by Feaganes et al. (2005) found that, after placing cameras in the cars of 70 volunteers over a period of one week, the main causes of distraction were eating and drinking, followed by distractions from inside the vehicle (which included looking and reaching for objects) and finally external distractions. They also found that these distractions resulted in a decreased driving performance. This was evident through the observation of the behaviour of the participants such as focusing on objects situated within the car instead of on the road.

Behm, Dalton and Kibele (2007) conducted a study to determine whether specific types of music and its volume have an influence on driving-related tasks. In their study the participants were exposed to different types of sounds at various volume levels ranging between 53dB and 95dB; the participants then had to complete various tasks in a random order. The results indicate that volume had a detrimental effect on movement, reaction time and simulated driving. The general findings are that loud sounds and music simply affect vigilance tasks while hard rock music appears to influence attention.

2.4.3 Music as a positive influence on concentration

Hallam and Schellenberg (2005) stated that whether music has a beneficial effect or not depends entirely on the listener. If an individual has a preference for hard rock music it could be beneficial to his or her performance and need not necessarily have a negative effect. A similar theory is apparent in research conducted by Hargreaves and North (1999) in which they found that the type of music a person chooses to listen to (their preference) when performing a task may increase that person's performance.

Husain, Schellenberg and Thompson (2002) indicated that a participant's spatial ability improves after being presented with high intensity music as opposed to low intensity music. Agnew et al. (2004), who looked at the effect of the preferred music of music students and non-music students on their selective attention, found that music facilitates processing, with specific reference to selective attention. They also found that instrumental music is more facilitating of processing than vocal music. This suggests that music could be productive and not just a distraction, but that this benefit may depend on the particular genre or type of music.

In an attempt to discover the effect of in-vehicle music listening, Dibben and Williamson (2007) include the results of a survey completed by 1780 respondents. The results obtained indicate that two thirds of the respondents prefer to listen to music while driving and that it is less distracting to them than a normal conversation. The respondents' reasons for listening to music were indicated to be for the purpose of relaxation and concentration.

2.4.4 Music as non influential to concentration

Is there a possibility that a person's concentration may not be influenced by the presence of music at all while driving? This is a strong likelihood to consider if one recognises that people may become habituated to driving, and that music may therefore no longer have a distracting or negative effect on drivers when such habituation occurs.

Galotti (2004) states that with practice, people learn to do many tasks simultaneously. When this occurs, more cognitive resources are available for other tasks, which imply that people can do several tasks simultaneously while driving. In many situations we are all required to process a great deal of information from a variety of sources and perform accordingly. A mistake in judgement however, could be fatal.

Concentration may change with practice - this means that practice may allow a person to perform a task without the input of any effort and little conscious attention; this is referred to as performance becoming automatic (Galotti, 2004). This implies that as driving becomes automatic, any detrimental effect associated with listening to music could begin to cause a decrease in concentration. Galotti states that “Practice thus appears to play an enormous role in performance and is one important determinant of how much attention any task will require” (2004, p. 119).

Other researchers such as Geringer and Nelson (1979), and Etaugh and Michals (1975) found that music rarely has an effect on a person’s cognitive performance.

2.4.5 Ambiguous results obtained from previous studies

Behm and Dalton (2007) set out to determine how tasks that are performed on a regular basis are influenced by the presence of music. The results indicate that music can have both a negative and positive effect on performance. Based on this, the assumption can be made that there is inconclusive evidence as to the effects of music on concentration.

They also found that music has a calming effect which effectively reduces stress and aggression as well as increasing performance (Behm and Dalton, 2007). However, other statements made by Behm and Dalton (2007) indicate that driving is impaired in situations in which music is present (taking into account the presence of many variables). These variables may include the tempo, type, duration, familiarity and/or volume of the presented music (Beh & Hirst, 1999, Behm & Dalton, 2007).

This suggests that individuals react differently to different tempos, intensities, genres and volume of music. These reactions may also alter according to the different situations in which individuals find themselves. These different reactions, elicited by different individuals, could be ascribed to their personalities. This study only explores the effect of tempo, and other factors are, therefore, not explicitly investigated; they are, however, taken into consideration when interpreting the results because it is understood that they may also have had an influence on the results.

Dibben and Williamson (2007) state that combining the tasks of driving and listening to music could result in either positive or negative outcomes. They maintain that the majority of existing research views music as a distraction and indicate that it does have an influence on driver mood, thus influencing driver behaviour.

Beh and Hirst (1999) state that it is not known whether high intensity music has an effect on behaviour and performance, regardless of whether the tasks require simple or complex performance. The abovementioned arguments provide motivation for further investigation as it is evident that there is no definite indication whether the tempo of music has an influence on concentration while driving.

2.4.6 The volume of music and its possible influence on hearing and health

The volume of music is the magnitude of the sound (Plack, 2004). The unit of measurement for the volume of sound is decibels of sound pressure level (dB SPL). This measurement determines the sound pressure level in relation to the lowest threshold, which is 0dB. Sound is regarded as a change in pressure when the perceived sound waves reach the ear. It is measured by means of this principle when sound waves reach the measuring device (Public Health, 2008).

In South Africa there are municipal laws which address the volume of music; however, these are not properly enforced. Authorities in the United States of America are concerned about the excessive volumes of in-vehicle music. In Florida there is a Bill in the process of being passed which seeks to penalise motorists who listens to excessively loud music while driving. This Bill states that music that is audible from a distance of 25 feet and more is punishable by law. Also, music that is perceived to create a disturbance of the peace, which implies that the volume of the music in the car is above a convenience level for the driver, specifically in areas with surrounding churches, schools and hospitals, is punishable (Herron, 2010).

In the past, this offence was enforced by the payment of a small fine; however, if this proposed Bill is successfully passed, the fine payable will increase and a point system will become applicable; thus, if too many points are accumulated, the driver's license could be suspended (Herron, 2010). In New York, police are impounding motor vehicles with loud car stereos: the owners of those vehicles are required to appear in court and pay a fine (Herron, 2010).

Herron (2010) discusses the health factors influenced by loud music, and also refers to factors such as driver emotions, road rage, physical effects and listening to the road. Driver emotions are dependent on the ability of a driver to manage their emotions while driving. When a driver is annoyed, irritated, upset or angry the likelihood increases that he/she may not be able to pay full attention to the complex task of driving. Herron (2010) says that driving in urban areas is currently a major cause of frustration and thus a driver's safety decreases immediately when he/she is caught in traffic and accompanied by excessively loud music.

In the United States of America, cases have been filed in which road rage was initiated by loud music. The physical effects elicited by music exceeding 90dB include an adrenaline rush which has the possibility of making people hostile (Herron, 2010). The range of 120dB to 130dB is said to be the threshold of pain experienced by a person's ears. Finally, the ability to hear the road while driving is important; a driver needs to do so while driving as this allows for the interpretation of important sounds. Certain sounds that an individual hears while driving will make the driver aware of the situations around him/her and provide the opportunity to react accordingly (Herron, 2010).

2.4.7 Types of hearing impairment due to loud volumes of music and noise

Sound levels below 70dB are said to have no risk of hearing loss but the amount of listening time beneath this volume level does increase the risk of hearing loss. However, listening to sound levels above 70dB and the duration thereof is considered to be important; if someone listens to music at a volume higher than 85dB for longer than 45 minutes a day, there are no risks involved. This however alters when one is exposed to music at this volume or higher for more than eight hours per day (It's your health, 2010).

Sensorineural deafness is a result of the exposure to loud sounds and noises regardless of their source. Another form of impairment is acute acoustical trauma which occurs when one is exposed to sounds that are over the 120dB to 130dB range; brief exposure to volumes of this level poses a danger to hearing. Noise-induced hearing loss can begin to occur when one is exposed to sounds over 90dB for long periods at a time (Brookhouser, 2000; Goodhill, Lambert & Shulman, 2000).

Temporary hearing loss that can occur due to exposure to loud sounds is referred to as temporary threshold shift (TTS). This is described as the short-term need for increased volume to be able to perceive sound after one has been exposed to loud sounds. If exposure to these loud noises becomes more frequent, this threshold may become permanent (Shoji, Takagi, Yamamoto & Yoneada, 1970).

2.4.8 Music as a background element

Background music according to Boyle and Radocy (2003) refers to any type of music that is played in the background while conducting another task simultaneously. Background music for all general purposes is only "intended to be heard but not actively or purposely listened to" (Mussulman, 1974, p. 93). The volume or level of loudness as stated by Boyle and Radocy (2003) is an important factor to consider when referring to such music. The purpose of this music is that it should be loud enough in order for a listener to be aware of it, however, it should remain unobtrusive. Obviously different volume levels are preferred by different individuals, however, when the volume level of music increases to such an extent that it is regarded as intrusive, it no longer serves the purpose of background music.

Furthermore, when attention begins to suffer as a result of the music, it cannot be classified as such music.

2.5 A GENERAL OVERVIEW OF THE BIOLOGICAL STRUCTURE OF THE BRAIN AND ITS FUNCTIONING

Thaut (2005) explains that music and speech are similar in terms of their general features: intensity, pitch, duration and inflection patterns. Furthermore, “in music the human brain creates and experiences a unique, highly complex time-ordered and integrated process of perception and action” (Thaut, 2005, p. 173). Thaut (2005) explains further that within the human brain there exists the ability to perceive and produce rhythm. The production and perception of rhythm requires the brain to be stable, rapid and precise. Based on this information one could infer that music’s tempo is possibly its most significant element and that the human brain is structured in such a way as to accommodate the perception of rhythm efficiently; it does so by ensuring that the processes work smoothly, quickly, and are faultless in their consistency when perceiving different types of rhythms.

Important aspects to be considered when evaluating the effect of music on cognition and behaviour are the structure and functioning of the brain, specifically, the auditory and visual processing neural networks. When exploring the information processing of both the auditory and visual networks it is important to consider the path these stimuli follow and the brain regions that are involved in information processing. The influence of music on performance relates to psychomotor behaviours wherein the brain serves the purpose of guiding the body in conducting motor-skills (Boyle and Radocy, 2003).

2.5.1 The physical structure of the ear

The physical structure of the ear consists of the *pinna,* which is the outer lobe of the ear which is visible to the naked eye. The hole in the pinna is the auditory canal through which incoming information (sound) passes in order to reach the *eardrum*. This is the division between the outer ear and the middle ear (Pickles, 1982). The eardrum receives and responds to incoming sound waves which cause pressure fluctuations and is extremely sensitive to any incoming pressure. Within the ear there are three middle ear bones known as the *malleus*, *incus* and the *stapes* which connect the eardrum to another membrane known as the *oval window*. This window separates the middle and inner ear. The sensitivity of sound perception is dependent on the oval window; if it is not responding optimally, the ability to perceive incoming sound is compromised (Durant & Ferraro, 2000).

The ear consists of *mechanical receptors* shaped in a hair-like form which are situated in fluid within the *cochlea*. Their main function is to determine the frequency of incoming sounds. Incoming external noise which is processed by mechanisms in the middle ear causes movement within the fluid; thereby movement is created within these hairlike structures which are connected to the *auditory nerve* (Culbertson et al., 2008).

From each ear, the auditory nerve passes an incoming auditory message ipsilaterally (on the same side as the incoming information) to the *cochlear nuclei* of the *medulla*. From here, pathways branch out in order to pass the incoming message to the *ipsilateral* and *contralateral superior olivary nuclei o*f the *medulla* (Culbertson et al., 2008). Culbertson et al. (2008) proceed to explain that the auditory processing system is different from the visual processing system because of its ability to receive input from both ears; this input is then passed on to each respective hemisphere. This process is formally referred to as *bilateral representation*. More specifically, messages entering the ear are picked up as wavelengths which enter the ear accompanied by *periodic pressure fluctuations* (Pickles, 1982).

Sound waves enter the cochlea, which is generally known as the inner part of the ear, by means of the oval window. Within the cochlea there are three fluid chambers; the *scala tympani*, *scala vestibuli* and *scala media* (Mathews, 1999). Wave-like movements within the scala tympani and scala vestibuli are created by stimulations that occur within the oval window. The waves entering the cochlea are different from the original, external sound waves. Depending on the frequency of the wave, an appropriate movement of the *basilar membrane* will occur. In perceiving a high frequency, the membrane will achieve maximum movement closer to the oval window. Lower frequency sound waves will elicit maximum movement in the membrane at the point farthest from the oval window, while a combination of frequencies excites the membrane at several points. This combination is most prevalent in music. The *sound wave perception* process described above provides background information for the understanding of frequency discrimination (Yates, 1995).

This process is embedded in energy that transmits sound signals by means of movement. *Audiocilia*, otherwise known as *Stereosilia* and collectively referred to as the *organ of Corti*, are situated alongside the *basilar membrane* which senses movement on the membrane and functions as a transducer. Simply put, the basilar membrane transforms one form of energy into another. Mechanical energy, once transformed, becomes *electrochemical energy* which is sent to the brain where auditory signals are initiated (Boyle and Radocy, 2003).

2.5.2 Brain regions and their functioning in auditory processing

Culbertson et al. (2008) explain that the *auditory pathways* proceed through the *lower brainstem* and come down through the *thalamus*; from here they then move into the *primary auditory cortex*. The latter is situated within the *temporal lobe* of each hemisphere. More specifically, it is situated within the *temporal lobe* on the *medial* part of the *superior temporal gyrus*, which is situated in the *lateral fissure*. This is known as the *Heschl's gyrus* and it processes "fragments" or pieces of sound. Culbertson et al. (2008) also point out that the primary auditory cortex consists of *frequency specific bands* that are situated parallel to the auditory frequency ranges on the cochlea.

In the study of both the auditory and the visual processes, there is a concept of a map: the *tonotopic map* (auditory) and the *retinotopic map* (visual). The retinotopic map relates to a visual map while the tonotopic map refers to information being transmitted onto the auditory cortex (Culbertson et al., 2008).

Certain bands within the primary auditory cortex are more attuned and receptive to certain frequencies than others. They also have the ability to process numerous elements of sound at any given moment; not only frequency, but also changes in incoming information, loudness and duration (Culbertson et al., 2008). The primary cortex therefore regulates the frequency, loudness and duration of incoming information: for the purpose of this study, that information is music.

Wernicke's area is situated on the *posterior side* of the *superior temporal cortex*. This region passes on the auditory information pathway after sound features are processed within the *secondary auditory processing area*. Here these features are converted into speech and sounds that are semantically interpretable. The function of the secondary auditory processing areas is to convert the sounds from the primary auditory areas (which are stored in the cortex) into meaning (Culbertson et al., 2008). The *supramarginal* and *angular gyri* of the *inferior parietal lobes* are joined with *Wernicke's area*. Here, visual and spatial information from the occipital and parietal lobes are associated with auditory information (Culbertson et al., 2008).

Earlier in this chapter, the bilateralism of the auditory functioning mechanism was explained. With reference to this it should be mentioned that there is a phenomenon known as *opposite hemisphere advantage*: this simply means that information obtained from the left ear is processed in the right hemisphere and vice versa. The left hemisphere, which deals with information obtained from the right ear, is more attuned to processing rhythm-based information (music or speech). This means that it is more attuned to perceiving the sequences of the sounds it obtains. On the other hand, the right hemisphere processes information based on tonality and this includes the melody of music and the tone of speech (Culbertson et al., 2008).

The right hemisphere however, first determines and recognises the relationship between the different sounds which are processed simultaneously; this is illustrated in the harmony of the music and chords, and the musical intervals between notes. Secondly, the right hemisphere deals with the recognition and processing of environmental and non-speech sounds (Culbertson et al., 2008).

2.5.3 The physical structure of the eye and processes involved in perceiving images

Just as is the case with auditory processing, there is no single region or neural network responsible for transforming visual information. Any perceived visual stimulus is a result of the integrated functioning of connected visual-perceptual processes (Culbertson et al., 2008).

Visual acuity has the ability to perceive light, to distinguish between light and dark, to resolve a target. *Receptors* on the other hand recognise the shapes of incoming visual information. According to Culbertson et al. (2008) the “what”, also known as the *ventral processing stream,* is controlled by the *ventral visual pathway* which leads to the temporal lobes. The “where”, also referred to as the *dorsal processing stream,* is controlled by the *dorsal pathway* which leads to the parietal lobes which controls spatial location.

The *ventral processing stream* specialises in object-recognition and consists of regions that are connected by the occipital lobe to the temporal lobe. The left hemisphere is more prone to recognising symbolic objects whereas the right hemisphere is more prone to identifying global images. On the other hand, the *dorsal processing stream* specialises in object localisation and connects everything from the occipital to the parietal lobes. Furthermore, the “what” serves the purpose of visual object recognition to a greater degree. Its purpose is to connect the shape and form of visual information and to represent the meaning of that shape and form. The “where” is essential for the placement of objects in a spatial setting so that the difference in distance and placement between objects can be determined. Furthermore, it assists in the planning and coordination of motor movements.

The “what” and the “where” are also defined by Atkinson and Hood (1997) who suggest that the latter is the location of an object which is identified by subcortical systems, while the former identifies a visual stimulus by means of the cortical structures.

Culbertson et al. (2008) describe *primary visual processing* as the reflecting of images on the retina. These images are then processed and matched to corresponding images by the retinotopic map in the primary visual processing area of the cortex. The eye itself is able to automatically adjust its focus to ever-changing conditions, including the ability to extract information from images that it processes.
The main structural units of the eye are cones and rods, which are known as *photoreceptor cells.* Their function is to process the incoming electromagnetic wavelengths of light so that meaning can be extracted from images. A specific

function of the cones is to recognise colour, whereas the function of the rods is to detect shades of grey. The latter are active at times when it is dark or in conditions of low-light. Each incoming field of stimuli projects to the opposite retina, thus information from the right visual field projects to the left retina and vice versa (Culbertson et al., 2008).

2.5.4 Brain regions and their function in visual processing

The occipital cortex and the temporal and parietal lobes are all involved in the processing of visual information. Certain areas of the frontal lobe are responsible for eye movement as well as the processing of visuo-spatial working memory (Culbertson et al., 2008).

Projected visual information leaves the eyes from the *optic nerve's* bundle of *axons* and these stimuli are then transmitted to numerous areas of the brain. Some of the neurons attach to the *hypothalamus* and the superior colliculus. However, the majority of neurons send visual stimuli with information to the occipital cortex. Thus, visual information is processed by passing through the eyes and following optic nerves to the *optic chiasm* which is situated on the *ventral surface* of the brain, and lies anterior to the *pituitary gland*. It is here where the visual information obtained from both the left and right eye joins and partially crosses (Culbertson et al., 2008).

After this occurs, visual information initially obtained from the left visual field is processed in the right hemisphere and vice versa. Furthermore, visual information is reversed from top to bottom, meaning that incoming visual information that entered at the top is reversed down to the bottom and vice versa. This causes information that is now at the bottom to be more closely situated to the temporal lobes and the information that is situated at the top to be closer to the parietal lobes. Now the optic tracts connect with the thalamus which is situated in the *dorsal region* on the *lateral geniculate nucleus* and information is finally projected to the *occipital lobe* (Culbertson et al., 2008).

The processing of visual information occurs in the *striate cortex* (primary visual cortex) and the *prestriate cortex* (secondary association). The former is situated in the most posterior part of the occipital lobes, of which a large portion stretches over to the medial part of each hemisphere. The retinotopic map referred to earlier in this chapter is situated here; its function is to ensure that all the meanings which are extracted from the visual information match that which is projected onto the retina.

It is important to determine which neural processes influence and are involved in attention. This issue is addressed in the next sub-section of this chapter. The aim is to determine which neural networks and regions overlap between auditory and visual information and attention, and also to discuss the influence of these elements on each other.

2.5.5 The purpose for describing the physical components of the ear and eye

As with any concept, it is important to understand the basic principles and processes before attempting to understand the major themes. The literature concerning the physical structure of the ear and eye is meant to help develop an understanding of the processing of music and the perception thereof by providing an in-depth overview of those processes from start to finish.

In general, the processing of visual information occurs mainly in the occipital cortex of the brain. However, the temporal and parietal lobes are also identified as having a role in the processing of visual information. Visual information, perceived from the left and right eye respectively, joins at the optic chiasm which is situated on the ventral surface of the brain, anterior to the pituitary gland. From here visual information is passed on to the thalamus, situated in the dorsal region on the lateral geniculate nucleus, and is projected to the occipital lobe.

The occipital cortex is not involved in the processing of auditory information at any stage, while the auditory cortex is not involved in the processing of visual information. However, the thalamus is the main sensory relay region for both of these senses, which transmits auditory information to the primary auditory cortex, and visual information to the occipital cortex. Auditory and visual information are therefore assumed to overlap in the thalamus (Culbertson et al., 2008).

Furthermore, Culbertson et al. (2008) state that it appears as though the auditory and visual sensory tracts also cross at the supramarginal and angular gyri of the inferior parietal lobes that join up with Wernicke’s area. This is therefore another region of interest as the concept of limited attentional resources referred to by Galotti (2004) could be applied both here and at the thalamus. If incoming visual and auditory information crosses at this region, it could be speculated that this is the location where attentional resources are limited as two stimuli are being processed simultaneously.

2.5.6 Brain regions and their function in attentional processing

Attention is defined by Culbertson et al. (2008, p. 240) as

> "[A] general level of alertness or vigilance; a general state of arousal; orientation versus habituation to stimuli, the ability to focus, divide, or sustain mental effort; the ability to target processing within a specific sensory arena, such as visual attention or auditory attention; or a measure of capacity."

Attention is thus regarded as multifaceted because it includes behaviour as well as cortical processes which are controlled by numerous subsets of cerebral structures. Existing theories of attention discussed by Culbertson et al. (2008), which refer specifically to the brain structures and regions involved in attention, including the subcortical structures and the cerebral cortex, were discussed earlier in this chapter.

In order for attention to be activated one must acquire a target so that a distinction can be made between relevant and irrelevant information. Relevant information will be processed whereas irrelevant information is discarded or simply ignored. Thus, if the attentional system is activated, it is possible to focus only on a small number of items of incoming information whilst ignoring the rest (Culbertson et al., 2008). This supports the statements made by Galotti (2004). Culbertson et al., continue their explanation of attention by saying that "attention operates as a gateway for information processing" (2008, p. 240). Thus it orientates, selects and maintains the focus on incoming information which is then made available for cortical processing.

The *Reticular Activating System* (RAS) controls the cortical activation level by setting a general cortical tone. This tone is observable through different types of brain waves which include the widely known beta, alpha, theta and delta waves and are measurable by the use of an Electroencephalogram (EEG). It is stated by Culbertson et al. (2008) that the sensory input received is responsible for charging and activating the RAS, but this does not imply that a lower type of sensory input is the cause of tiredness. Rather, when sensory input is constant and occurs on a regular basis, habituation can occur - this could refer to fatigue while driving. The RAS is also suggested to be anticipatory as it sends a preparatory signal to the cortex in order to warn it to expect and receive an incoming stimulus. This causes an increase in the cortex's readiness to receive that specific stimulus (Culbertson et al., 2008).

As with auditory and visual information and processing, the regions in the brain related to attention do not act independently from one another, but are dependent on each other to sustain attention (Culbertson et al., 2008). One of the areas involved with this is the *right fronto-parietal-thalamic neural network* (Bruno, Givens & Sarter, 2001). Other regions involved in selective visual attention include the thalamus, the basal ganglia and the *superior* and *inferior colliculi*. The thalamus, specifically, is activated by reticular formation, and this arousal is sent to the cortex. Moreover, the thalamus also selects and sends information back and forth between the subcortical regions and the cortex. Furthermore, cortical neural signs are projected to the subcortical regions. This entitles the thalamus to determine which incoming stimuli to focus on and thus it is seen to have an important role in selective attention (Cohen, 1993).

The superior colliculus, originating in the midbrain, has an influence on reflexive eye and head movement when orientating oneself to incoming visual stimuli. The inferior colliculus on the other hand is involved with the orientation of auditory stimuli (Culbertson et al., 2008). DiGirolama and Posner (1998) state that the basal ganglia functions entail the shifting of attention between different areas of focus. This is illustrated in the focusing of visual attention on external objects. The basal ganglia act as the region which controls the shift of the eyes between different points of focus.

However, one region that processes auditory and visual stimuli independently includes both the superior and inferior colliculus. Because of this, no overlap or competition for attentional resources is expected to occur in this region. The *cerebrum* is indicated to be responsible for attention processes in the *cerebral cortex*. This includes focused attention, divided attention and sustained attention.

Focused attention is the ability to react to situations based on incoming visual information. *Divided attention* on the other hand includes more than just the processing of visual and auditory information simultaneously. Here it enables one to be able to focus on the road ahead, shift gears, listen to a conversation or be able to talk with someone, and be able to focus on what is playing on the music system. Finally, *sustained attention* refers to maintaining vigilant while driving.

Is it possible to divide one's attention between one stimulus and another or have individuals learn to simply shift their attention from one stimulus to another? Research has indicated that individuals are able to divide their attention but only to a certain degree (Culbertson et al., 2008). This creates another point of discussion: if attention can only be divided to a certain degree, what is that degree of divided attention? Is this ability influenced by other factors? These questions are not addressed in this study; however, they could be suggested for further research on this matter.

Another important factor is that attention is also described as either a task, or an information-processing demand. Aston-Jones, Cohen & Gilzenrat (2004) stated that regular tasks may be performed automatically at a later stage when the minimum mental resources are required; this means that processing demands are low and that several tasks can be performed simultaneously. However, the opposite is also true: tasks that are unfamiliar or new to a person may require more mental resources. Controlled processing requires a large amount of mental resources which occur in a linear or serial manner. For this reason it is generally impossible for the parallel processing of other tasks to take place at the same time (Aston-Jones et al., 2004).

According to Lee (2007), individuals who are new to driving, also referred to as novice drivers, are more likely to be influenced by other factors and circumstances around them as opposed to more experienced drivers. Such a *novelty effect* is proposed to be irrelevant when sufficient experience is gained, but until such a time, an individual would most probably struggle to perform more than one task simultaneously while driving. The assumed reason for this is that there is a limited availability of mental resources. When an individual has acquired sufficient information from the visual field, habituation takes place. The concept of *visual* *habitation* is based on the proposition that the scanning of a visual field facilitates subsequent access to the content of this field (Atkinson & Hood, 1997).

2.5.7 Eye movement and its proposed influence on attention

Eye movement is associated with a shift in attention and can occur in one of two ways; *exogenous* and *endogenous* movement. Exogenous movement takes place when an external visual stimulus is observed while endogenous movement is internal and occurs when a person searches for something specific. Exogenous eye movement is said to be reflexive implying that eye movement is an automatic response to external visual stimuli. Endogenous eye movement on the other hand is said to be voluntary. Adults are able to switch between both exogenous and endogenous modes. The extent to which this occurs, however, depends on the specific stimulus conditions (Atkinson & Hood, 1997).

Exogenous and endogenous eye movement entail the movement of an individual's eye; this is caused by distractions from both inside and outside the vehicle (in a driving context). If an unexpected object, such as a ball rolling across the street, suddenly moves into the visual field of a driver, then exogenous eye movement occurs. However, if a driver intentionally moves his eyes from the road to the radio in order to change the channel or adjust the volume, then an endogenous eye movement takes place.

Selection for action is an important part of attention; this concept entails observing and processing incoming stimuli which are then linked to an appropriately related action pattern. Simultaneously, intrusion from any other incoming stimuli is avoided (Atkinson & Hood, 1997).

2.5.8 Relevance of brain anatomy in the study

Coull et al. (2004) conducted a study in which participants were required to perform a spatial working memory task as well as a spatial orientation task. The requirements for each of these tasks included internal and external stimuli representation. While performing these tasks, fMRI results indicated that there was an overlap of neural networks in which frontal, occipital and parietal cortices were involved for information processing. The superior parietal lobe was involved with both tasks; however, the right inferior parietal cortex was selectively involved with processes related to external stimuli. Within the frontal lobes, external stimuli were involved with the activation of the pre-motor and the dorsal prefrontal cortex. The anterior prefrontal areas, on the other hand, were more involved with internally represented stimuli. The findings of this study conducted by Coull et al. (2004) suggest that there is an overlap in the brain's neural networks and that this overlap is involved with both external and internal spatial representations.

Studies such as the one described above suggest that although auditory and visual information are based on different neural networks, these two mechanisms could indeed have a reciprocal effect on each other.

Berlyne (1971) bases his consideration of moderate types of music on a psychobiological approach. He argues that the auditory nerve moves to the cortex and passes through the ascending reticular activating system (ARAS) which is responsible for the amount of arousal one may experience. It should be noted that the cortex is the higher brain region which is said to be responsible for conscious thought. It can therefore be deduced that certain types of music, which elicit a higher arousal level, pass through the auditory nerve and thus cause an even higher degree of arousal.

The ARAS passes through the pleasure and displeasure regions of the brain; Berlyne (1971) suggested that moderate type music would be the preferred type of music because of the amount of activity produced in the ARAS. An increased level of arousal tends to consist of a lower threshold as opposed to moderate music. This statement implies that moderate music only causes activity in the pleasure regions of the brain and does not really activate the displeasure regions, whereas music with a high arousal level activates both the pleasure and displeasure regions of the brain. This phenomenon is illustrated by the inverted-U relationship in Figure 2.1 (Berlyne, 1971).

Boyle and Radocy (2003) point out that the investigation and inclusion of models pertaining to attention are vital in the case of an aesthetic experience with music or in an instance in which preference for certain types of music is determined.

Atkinson and Hood (1997) refer to a selection-for-action principle in which certain limitations appear to arise. Included in this is the fact that there are a number of competing actions involved in the assignment of priority to perception, which is determined either by the internal states or the relative prominence of each competing stimuli. The strength presented by each of these stimuli is determined by their characteristics such as colour, size, contrast, whether they are dynamic or static, and whether one stimulus is similar in time, position and distance to other stimuli.

The processing of neural networks is conducted prior to reaching the auditory cortex, despite it being the end destination for incoming sound stimuli. Subcortical regions are employed to make decisions based on musical stimuli beforehand (Boyle and Radocy, 2003). The afferent and efferent neural pathways are important in relation to the perception of music: the former describes the process in which incoming information is perceived and organised into understandable information, while the latter ensures that a neural network exists for alerting the cochlea to particular sounds (Boyle and Radocy, 2003). The afferent neural network sends impulses into the brain whereas the efferent neural network sends impulses from the brain (Mathews, 1999).

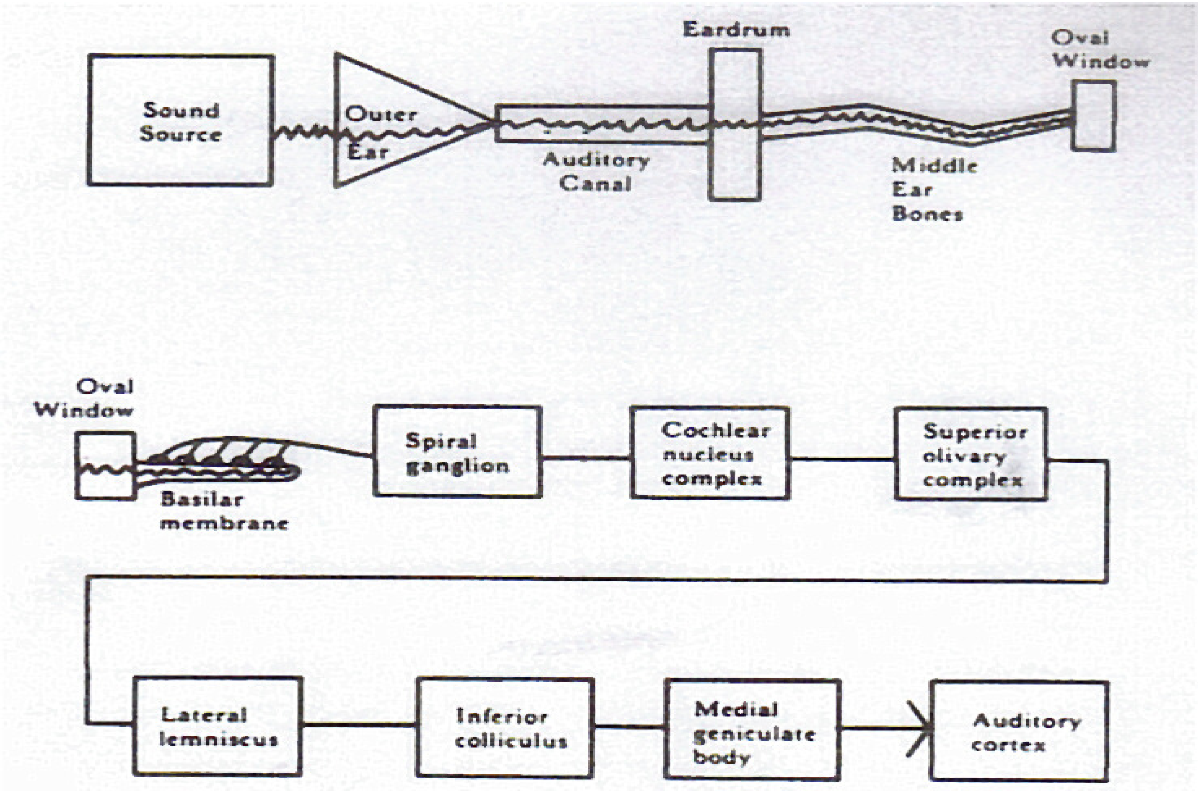

Figure 2.1: *Diagram of auditory transmission from sound source to auditory cortex* (Boyle and Radocy, 2003, p. 100).

2.6 MUSICAL PREFERENCE AND ITS INFLUENCE ON AROUSAL

A person's preference for a certain type or genre of music can be ascribed to many factors. Hargreaves and North (2008) postulate that memories and the emotional reactions elicited by specific music can determine this preference. This, however, poses a great challenge for the investigation of music and psychology according to Hargreaves and North (2008). These authors consider music, the listener and the context of the listening to be determining factors.

Isolating the music itself, two theories are referred to by Hargreaves and North (2008). These are the physiological effects of music based on arousal and cognitive factors. Berlyne (1971) refers to the arousal potential of musical stimuli and the effect these have on the RAS, on the amount of activity they are able to elicit. Hargreaves and North state that “music with an intermediate degree of arousal potential is liked most, and this degree of liking gradually decreases towards the extremes of arousal potential” (2008, p. 77). An inverted-U relationship between music and stimulus arousal thus exists and is illustrated by the Wundt curve, shown below (Hargreaves and North, 2008, p. 77).

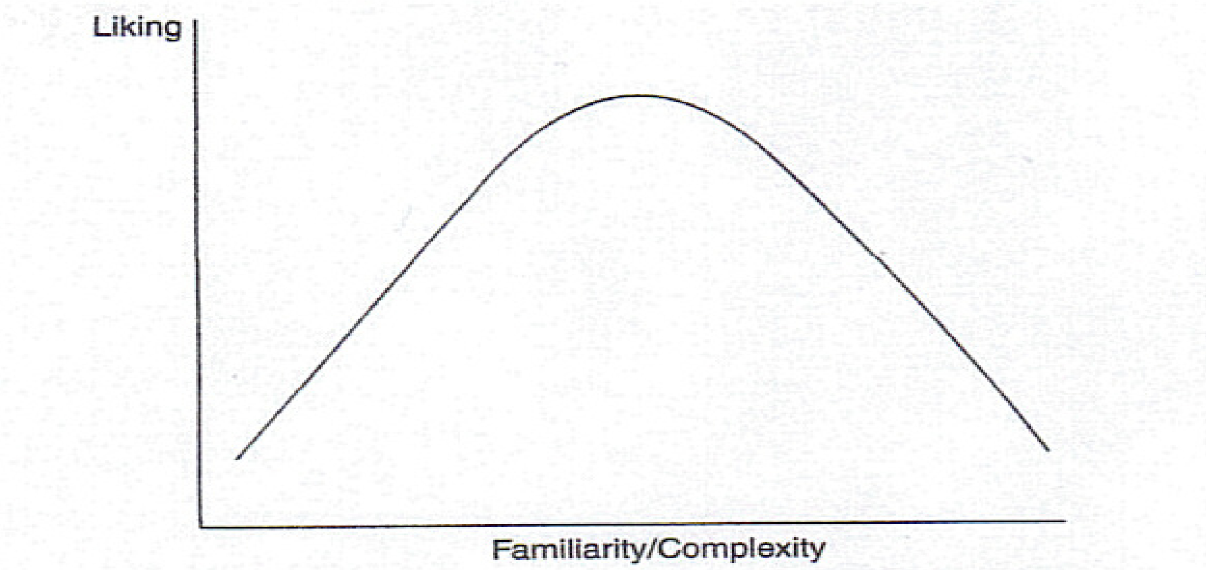

Figure 2.2: *The relationship between musical familiarity/complexity and liking* (Hargreaves and North, 2008, p. 77).

This graph, as illustrated in Hargreaves and North (2008), provides a graphical indication of the relationship between the familiarity of music to a person and the effect of this on the enjoyment of that specific music. Berlyne (1971) mentions the three variables that could be the cause of arousal: psychophysical, ecological and collative variables. Collative variables are a collective term for “properties of stimulus patterns as novelty, suprisingness, complexity, ambiguity, and puzzlingness" (Berlyne, 1971, p. 69).

Psychophysical variables are the physical properties of music such as the tempo or volume; thus "music is said to possess more arousal potential as it gets faster and louder" (Hargreaves and North, 2008, p. 78). The term ecological variables refers to the meaningfulness of music while collative variables are the information properties of music that are determined by music's degree of unpredictability. This relates to the complexity of the given music and the listener's familiarity with it. The level of complexity is the degree to which a certain type of music in unpredictable to a listener: as the complexity increases, more arousal potential is elicited. Familiarity with certain types of music is said to decrease the amount of arousal potential it elicits (Berlyne, 1971).

Heyduk (1975) discusses the novelty and complexity of music and the effect that it may have on the listener. It is said that when a new piece of music is heard, it automatically contains a sufficient amount of information to be perceived. However, as that piece of music is listened to more frequently, the complexity decreases as it becomes more predictable. The ideas discussed by both Berlyne and Heyduk can be applied to this study even though they are more pertinent to musical preference.

The listener, as the second major theme to be explored in this study, includes variables such as age, gender, background in musical training, socio-economic status, ethnicity and personality. All of these variables are factors which contribute to an individual's musical preference (Hargreaves and North, 2008). Referring to socio-economic status, it is suggested that such a preference is influenced by social stance; this is understood to be the extent of one's inclusion in and membership of a certain group and culture (Hargreaves and North, 2008).

With regard to age, it is said that with age one acquires the ability to process more complex music such as classical and jazz. As people grow older, their musical preferences tend to shift from the right-hand side of the inverted-U to the left-hand side. This implies that music which is too complex for children will be more optimal for older people. The converse should also be true, namely that musical pieces that are optimal for younger people will be too simple for older people (Castell & Hargreaves, 1987). In conclusion it can be said that musical preference is determined by age (Hargreaves and North, 2008).

2.6.1 A prototypical model for preference

A prototypical model refers to the preference for certain things that one can classify easily, in other words, things one is familiar with. Daily experiences are said to be more easily classified if they match an existing experience or prototype that has already been created. By means of experience and continual exposure, these prototypes are created; this is more simply described as life experience (Hargreaves and North, 2008).

2.6.2 A reciprocal response model of music, the listener and the listening context

Continuing with the discussion of music, the listener and the listening situation, Hargreaves and North (2008) discuss a reciprocal feedback response model for music in which they attempt to combine these three factors. It is referred to as a feedback model since these factors are bi-directional in their ability to influence one another.

The diagram below indicates that certain types of music fit specific contexts better than others based on the relationship between music, situation and context. The interaction between 'situation' and 'context' and the 'listener' illustrates that people make use of music in order to achieve their goals. The 'listener' and 'music' indicates an individual's response which is determined by their personal taste in music (Hargreaves and North, 2008). This model focuses mainly on musical likes and dislikes and excludes emotional reactions. Also, it is more indicative of short-term reactions to music rather than long-term considerations regarding musical taste and preference.

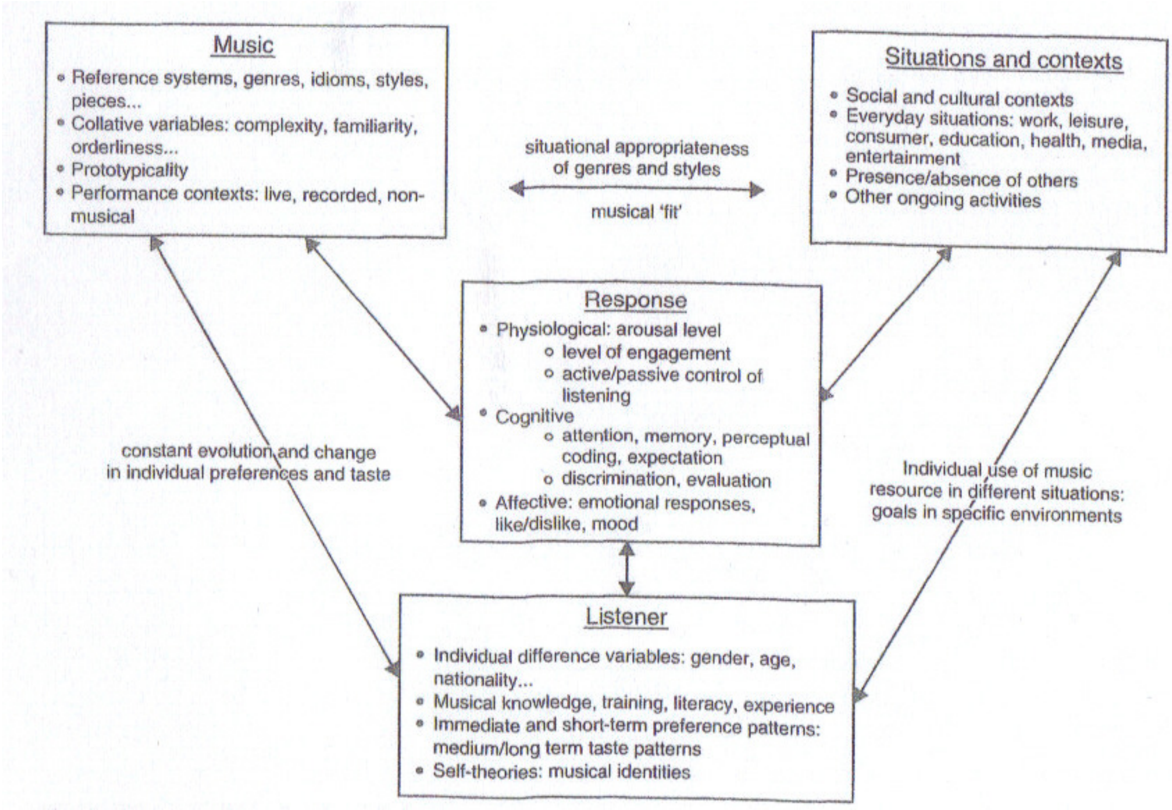

Figure 2.3: *Reciprocal feedback model of musical response*

(Hargreaves and North, 2008, p. 124).

2.7 EMOTIONAL RESPONSE TO MUSIC

Hargreaves and North (2008) explain that emotional responses to music are difficult to determine because it is difficult to place emotions in theory; emotions vary from one individual to another, can change over time, and problems exist in the validity of observing emotions. Meyer (1956) argues that a musical piece has culturally determined intrinsic and extrinsic meaning and that a person's ability to determine what will follow in a given musical piece is based on knowledge about these musical cultures. Extrinsic musical meaning implies that the meaning acquired from music is obtained from the extra-musical and contextual associations related to the sounds (Hargreaves and North, 2008). Two factors are explored which are known causes for emotional responses to music: these are associative and iconic cues. The latter relate to certain parts of the music which are associated with particular emotions (Hargreaves and North, 2008); with regard to iconic cues, Bruner (1990) associated certain factors (pitch and time) of music with emotional responses. Thus, music which has a fast tempo is associated with happiness.

A finding of Hargreaves and North's research is that high arousal music and its inducement of excitatory behaviour could lead to an increase in happiness. This reinforces Bruner's statement that high tempo music is associated with happiness. Happiness may not necessarily lead to negative consequences; however, happiness is associated with excitedness, which is claimed to negatively influence the attentional resources available to other incoming stimuli. Hence, music employing a higher tempo may be the cause for a decrease in concentration.

Boyle & Radocy (2003) distinguish between stimulating and sedative music. The former induces a high level of arousal in the listener due to its energetic content. Rhythm and tempo are considered to be a strong energising factor. Volume level is also perceived to influence physical response; therefore louder music elicits an increased physical response as opposed to softer music. Softer music is associated with calm and tranquil behaviour. Sedative music contains minimal rhythmic beats and is limited in its frequency range (Boyle & Radocy, 2003).

Different types and genres of music may elicit diverse reactions in different people. Boyle and Radocy (2003) illustrate this by making referring to the military, school pep rallies and marching bands which are all normally exposed to rousing music which achieves ‘excitedness’. This is in contrast to sedative music that is often used to soothe and calm infants. A study conducted by Akai, Nakajima, Nittono and Tsuda (2000) in market research indicates that music consisting of a higher tempo in the background causes an increase in the working speed as regards a tracing task being undertaken by undergraduate students. Some general conclusions drawn from this study are that customers tend to move quicker through a commercial establishment when higher tempo music is played as opposed to slower tempo music.

The tempo of music is regarded as the element in music that determines whether it is stimulating or sedative. The elements of rhythm and the consequences of these elements imply that accents in music which occur in typically unaccented places may result in feelings of excitement and tension. Rhythms that are repeated throughout the track may cause an increase in psychological intensity (Boyle and Radocy, 2003).

2.7.1 The ‘Power Law’

Many aspects of human learning can be described as in accordance with the Power Law which assumes that “a lawful relationship exists between an increasing physical stimulus value and the rate of growth in some associated psychological response” (Boyle and Radocy, 2003, p. 123). The relationship observed between these two factors is indicated by means of a decimal exponent, also referred to as a power function. This is said to provide an indication relative to the size of a response ratio, which is a result of the stimulus ratio.

According to Boyle and Radocy, “Affected responses to music are largely covert” (2003, p. 312). When studying these responses one may encounter difficulties when attempting to measure music cognition. Observed behaviour is used to describe affective response based on conclusions drawn from psychological constructs. Reference is made to affect, emotion and aesthetic.

Affect relates to thinking, feeling and doing and is classified into cognitive, affective and psychomotor behaviours (Boyle and Radocy, 2003). Feelings are proposed to be caused by the arousal of a stimulus which is then perceived to influence human behaviour. The intensity of the affective response varies according to time and situation. It is said that affective processes are related to and influenced by every element that can be classified as psychological; these are perception, memory, learning, reasoning and action. Behavioural affect, as referred to above, is indicative of a disruption from the normal emotional state and is influenced by the emotions that music evokes.

2.8 RELEVANCE OF THE REVIEWED LITERATURE TO THIS STUDY

As the study is based on the relationship between cognitive function and attention, it is only natural that the underlying theoretical paradigm employed is that of cognitive psychology. Music as a distraction and the cause of a decrease in concentration is grounded in the theory of attention. In this study the aim is to observe concentration externally by recording the behaviour of participants who take part in a simulated driving task.

When a person is driving, he/she has to focus on numerous stimuli. These are the visual information obtained from one's immediate surroundings and the auditory information from either a conversation with a passenger, the radio, or music playing from a disk. When incoming visual information is being processed, the driver has to process that specific information and then act appropriately. If driving is accompanied by auditory stimulation, that information is processed simultaneously with the visual stimuli. Is it then possible that auditory information interferes with visual information being processed and acted upon? Does this influence the amount of attention one is able to apply to a given task?

Music, and specifically high tempo music (HTM), is proposed as a distraction factor for concentration. As stated with reference to Galotti (2004), it is assumed that there is a limited amount of attentional resources available for the perception of stimuli. The complexity of a stimulus determines the amount of attentional resources still available which may be employed for the processing of additional tasks. Some of these tasks include focusing on the road, or listening to music.

The opposite effect may also be plausible: one's concentration may be so focused on the task of driving that the music is completely blocked out. In this case the music would then be a background which is only audible enough for one to be semi-aware of it, such that it does not occupy all of one's thoughts and attentional resources.

In order to determine if this is possible, an investigation was conducted which included existing literature dealing with the neural pathways of the auditory and visual networks in order to determine whether there is an overlap between these neural networks. This however, is only based on speculation as no actual research was conducted to investigate the brain and its functioning. Therefore, conclusions are based on that which has been found by other researchers.

2.8.1 Supporting evidence for the proposed study

With regard to attention, HTM is said to be a possible distraction. Attention is focused on the act of driving which involves internalising visual information and reacting appropriately. If the tempo of music, more specifically HTM, is indeed a distraction, then concentration is limited due to visual stimuli in a required space of time due to the limited cognitive resources which prevent the appropriate reactions form being elicited.

Visual and spatial information at the supramarginal and angular gyri of the inferior parietal lobes joined with Wernicke's area may cross with auditory information. This is illustrated by the ability to listen to music while driving and to process streams of visual information. It is here that the proposed relationship could occur.

In the processing of auditory and visual information, the thalamus plays a central role in sustaining attention. This could imply that listening to in-vehicle music limits the amount of concentration available for the task of driving. This may be due to the fact that one region of the brain is central to the processing of both auditory and visual information and therefore to the maintaining of attention; this region is the thalamus. Although the thalamus is involved in the processing of both types of information, it should be considered that it may possibly only act as a relay station for these separate sets of information as they move to their respective end destinations.

Furthermore, Culbertson et al. (2008) also assert that auditory and visual stimuli cross at the supramarginal and angular gyri of the inferior parietal lobes that join with Wernicke's area. This provides supporting evidence for the notion that there may be competition for attentional resources.

Boer et al. (2006) stated that performing two tasks simultaneously has an influence on performance ability. In the context of this study this could mean that when one is driving, which requires the use of visual sensory modality, and listening to music, which requires the use of auditory sensory modality, concentration could be impaired.

Also, it is possible that musical tempo only has a detrimental effect on concentration and driving ability when one is driving in a more complex context, such as peak-hour traffic, an area with many pedestrians, or hazardous weather conditions.

As this study is focused on the tempo of music as the main element of investigation, it is important that tempo and the concept of music be discussed for background purposes. If the volume of music is so high that it creates a disturbance, it is no longer regarded as background music. For this reason volume is assumed to play an influential role in the perception of music and is thus included in the study. More important, however, is that loud music poses a risk to a person's health.

2.8.2 Literature disproving the proposed relationship between the tempo of music and concentration

Findings based on studies conducted by other researchers and inferences drawn from their results indicate that the primary cortex is the region responsible for selecting information to be perceived (Culbertson et al., 2008). This means that music is regulated by means of the primary cortex which determines what elements of the music must be perceived and passed on. If some elements are not perceived, does this simply mean that they are disregarded? This query implies that unexplained issues remain, regarding whether there are elements of sound that are not explicitly processed. This could be indicative of what Galotti refers to as selective attention.

As mentioned, research also indicates that music entering the ear canal through the right ear will be processed by the left hemisphere, which processes rhythm. However, it appears as though the right hemisphere has priority when information is being processed. This implies that speech obtains precedence over tempo when it comes to auditory processing. This could imply that the tempo of music may not influence concentration as originally stated in H1.

Literature regarding music as exerting no effect on concentration while driving indicates that individuals have the ability to multi-task (Galotti, 2004). This is said to be applicable to individuals who are experienced drivers; they have learned how to conduct multiple tasks at any given moment. Furthermore, if a task is performed on a regular basis, very little mental effort is required as the performance of such a task becomes automatic (Galotti, 2004). This implies that tasks that become automatic, such as driving (for experienced drivers, will not be influenced by the presence of music. Practically, many people attest to having, at some stage driven from one point to another yet afterwards not being able to remember exactly how they got there. This is an example of a task becoming automated. In such an instance, music is acknowledged as not having an influence on a driver's concentration.

2.9 CONCLUSION

Numerous different topics, all relating to concentration have been explored. With regard to the brain regions involved in concentration and the processing of visual and auditory information, the thalamus presented itself as the one region in the brain which processes information for the two sensory modalities. The thalamus does, however, only appear to be a relay station. Furthermore, both the auditory and visual sensory tracts are indicated as crossing at the supramarginal and angular gyri of the inferior parietal lobes which are joined with Wernicke's area. The latter is responsible for the understanding of speech (Cherry, 2011).

Joseph (2000) indicated that the supramarginal and angular gyri, which form part of the inferior region, are situated at the junction of the temporal-, parietal- and occipital lobes. This possibly confirms the overlap in perceived visual and auditory information, which, for the purposes of this study, is applied to the context of driving while listening to in-vehicle music.

The proposed relationship between the tempo of music and concentration may therefore enjoy theoretical support. This support is found in the finding that attentional resources are limited due to the overlapping of the two sensory modalities at more than one region in the brain. The problem, however, is that this overlap in sensory tracts is not scientifically investigated in this study and can therefore only be presented by referring to the findings of other theorists. If the context of the driving situation is more complex (high traffic or bad weather), then there is a greater likelihood that some stimuli may not be perceived, but filtered out; this concept is based upon the filter theory This implies that the complexity of the driving situation is also a determining factor of the perception of auditory and visual information and determines which sensory modality takes precedence over another.

However, Grahn's (2009, p. 268) statement that "two overlapping but functionally independent neural populations are present and active within a common region" does not necessarily imply common functioning. This could mean that although overlaps have been detected in the neural processing of visual and auditory stimuli, this does not signify that a specific area is functional for both, while there could indeed be no interference at all. Furthermore, 'anatomical connectivity' (Grahn, 2009, p. 269) cannot provide conclusive evidence that connections throughout the human brain are employed and activated at the same time. 'Functional connectivity' in turn is indicative of a correlation between different regions but cannot provide supporting evidence that one area exerts a direct influence on another.

For the purpose of including other relevant factors that could influence the study and the results, an in-depth reading into the emotional responses elicited by music and the personal preference for different genres was included as these two factors are seen to be very influential. These factors were acknowledged and discussed, but they were not included for observation in the study as the main focus was to determine the effect of the tempo of music on concentration while driving, and in turn, its influence on driving behaviour.

It is evident from this review of existing research that the results obtained in the past have been ambiguous with regard to the actual effect of music on concentration and driving ability. Furthermore, speculations about the proposed relationship between the tempo of music and concentration undertaken by the lay person have made it evident that this is a worldwide occurrence. After thorough exploration of the subject, the conclusion was drawn that further investigation is required, and thus this study was proposed.

The gap identified in this field is not that there is a lack of research investigating the proposed relationship, but rather that there appears to be a lack of agreement between researchers as to the actual effect of music on concentration while driving. Most existing studies report findings of a negative, positive or even no, relationship between music and concentration. This presented the opportunity to employ and adapt existing methods to determine the effect of music on a driver's concentration from a new and modern perspective.

CHAPTER 3:

METHODOLOGY

3.1 RESEARCH DESIGN

The aim of the study is to investigate the amount of driving errors (DE) made in the presence of no-music (NM), low tempo music (LTM), medium tempo music (MTM) and high tempo music (HTM). By means of observing and recording the amount of DE, it should be possible to determine whether the tempo of music has an influence on concentration while driving.

Based on this, the appropriate question is whether the tempo of music causes a decrease in concentration while driving; and in turn does this influence driving ability? In order to explore this suspected relation between the tempo of music and concentration, it is hypothesised (H1) that the tempo of music does influence concentration while driving. It is also hypothesised (H2) that HTM causes a greater decrease in concentration when driving as opposed to LTM and MTM. Finally, it is hypothesised (H3) that the tempo of music has an influence on driving behaviour.

The study aims to provide answers to the following research questions:

1. Does the tempo of music have an influence on concentration?
2. Does HTM have a bigger influence on concentration as opposed to NM, LTM or MTM?
3. Does the tempo of music have an influence on driving behaviour?

Participants were subjected to an experimental setting in which the experience of driving was simulated by means of a Sony Playstation 3; the equipment employed is specified later in this chapter. This study does however not create a true experience of a real-life driving context in which factors such as traffic and weather conditions are present, but, rather, the 'experience' of driving was merely simulated. For this reason, the research cannot be regarded as founded on a real-life driving experience.

The study is based on a quantitative research approach and a quasi-experimental research design is utilised. In reality, it is nearly impossible to conduct a study in which a researcher is able to create an accurate representation of what he/she wishes to investigate. Also, certain concessions with regard to conducting a quasi-experimental study have to be taken into account; thus issues such as the costs involved in recreating the specific study, the availability of instruments and technologies, as well as the participants who will be involved in such a study, need careful thought. The advantage of a quasi-experimental design is that it creates a research condition in which a researcher is able to collect data that is as close to true experimental conditions as possible (Forzano & Gravetter, 2006).

The research design utilised can thus be referred to as a quasi-experimental study due to driving being simulated and not occurring in a natural driving environment, even though the treatment conditions were randomized and manipulated which was an attempt to exert some form of control over the research process in order to obtain meaningful, valid and reliable results. Furthermore, due to inadequate funding and other possible issues discussed in the following section it was the best solution to approach the study in this manner with the intent of controlling the research setting to some extent without applying rigor control that would have suppressed behaviour that would otherwise not have been observed naturally.

3.2 THE DEPENDENT AND INDEPENDENT VARIABLES

Dependent and independent variables are those factors which create a cause-and-effect relationship (Forzano & Gravetter, 2006). Information regarding this relationship is what is sought in this study, which is acquired by means of the quasi-experimental research design chosen. The dependent variables investigated in the study are concentration and driving ability. These were chosen directly from the research question: does the tempo of music have an influence on concentration while a person is driving and in turn influence his/her driving ability? Thus, the susceptibility of the two constructs to being influenced by the tempo of music is analysed.

The independent variables include four different music treatment conditions: the NM control condition and the LTM, MTM and HTM treatment conditions. The aim of the study is to apply each treatment condition to the task of simulated driving; this is in order to measure the effect of each treatment condition on concentration and driving ability. A one-way analysis of variance (ANOVA) will be conducted on the results in order to compare the four treatment conditions with regard to their influence on the dependent variables.

3.2.1 Confounding Variables

Confounding variables refer to any variables that are not identified and included in the study's design. Some confounding variables which were identified as possibly having an influence on the results included fatigue, the emotional state of the participants, and the novelty effect.

A benefit of the experimental research design is that it takes many of the confounding variables into account, thus controlling each of the identified variables (Forzano & Gravetter, 2006). Some potential confounding variables in the study needed to be identified, described and included in the study in order to eliminate them as factors which may have had an influence on the dependent and independent variables as well as the results.

3.2.1.1 Fatigue

To exercise absolute control over the fatigue of the participants in any study is impossible. Fatigue in this instance refers to any tiredness which impairs concentration while driving. However, one possible solution to minimise the effect of fatigue was to inform the selected participants that in order to obtain optimum results, a good night's rest was required; preferably seven to eight hours of undisturbed sleep. Participants were requested via email to acquire a good night's rest and were reminded again one day before the study. By enforcing this precaution, poor concentration on the day of the study could be minimised; thus the assumption can be made that optimum results were obtained for each participant. It was however, up to each participant to ensure that they followed the instructions. Participants were asked to indicate whether they had done so and were also required to indicate the amount of sleep they had obtained the night before the study.

One participant complained of fatigue even though the LTM, MTM and HTM treatment conditions were randomised. They were randomised in an attempt to eliminate fatigue; however, this participant's fatigue was ascribed to having looked at a computer screen for a long period of time. Furthermore, the fatigue could also have been due to the repetitive nature of the task; the simulated track which participants had to drive on remained the same throughout the entire study process.

3.2.1.2 Emotional state

The emotional state of the participants was another confounding variable identified as having a possible influence on the results. No precautionary measures are possible to prevent a participant from experiencing a traumatic event or negative emotions. The questionnaire required that participants identify their mood. Participants who felt emotionally unwell on the day of the study may have contributed to poor results which could have negatively influenced the general statistics. Participants were informed, however, that they were free to withdraw from the study at any stage if they felt the need to do so.

3.2.1.3 Novelty effect

The possibility that participants were overwhelmed by the simulated driving experience was considered, as it was each participant's first time to experience console gaming on a Playstation 3; this is an example of the novelty effect. Lee (2007) explains that individuals experiencing this novelty effect could easily be overwhelmed, or even unable to perform numerous tasks simultaneously. He states that novice drivers are more commonly exposed to new technologies while driving, these including the use of mobile phones and MP3 players. Using MP3 players for example, requires an individual to make adjustments; if this individual is regarded as a novice driver, the shifting of attention may be detrimental to his or her driving performance.

As indicated above, none of the participants had ever used a Playstation previously. In order to account for this novelty effect, all of them were required to take part in a practice session before the study. This occurred under the supervision of the researcher, and allowed the participants to familiarise themselves with the task at hand. This practice session was included in order to reduce the novelty effect so that the participants could partake in the study without being overly influenced by the new experience of simulated driving.

3.3 HOW THE STUDY WAS REFINED

When the researcher was initially contemplating the manner in which to conduct the study and the processes required for obtaining data, there were numerous variables to consider. Based on financial restrictions and ethical considerations, it was decided to conduct the study on a Playstation 3.

Other options that were considered included placing participants in a real-life driving context and observing their behaviour. However, due to extraneous variables such as traffic and weather conditions and the participants' personal safety, this was not feasible. Behaviour which was to be elicited by individuals in this scenario was assumed to be unrealistic due to the presence of the researcher in the passenger seat. An alternative option, which was considered, was to place video cameras in the motor vehicles of volunteers in order to record natural driving behaviour without the intrusion of an observer. However, due to the invasion of privacy, this option was ethically not feasible to implement. Another option was to conduct the study at a racing track or to utilise a simulator, but due to budget constraints this was not possible either. After exhausting all other possibilities, the decision was made to conduct the study using a Playstation 3

.

3.4 SAMPLING PROCEDURE

A non-probability sampling method was employed. More specifically, a convenience sample was selected for the purpose of the research; individuals who indicated their willingness to participate in the study were included, provided that they met the pre-determined requirements.

Eight participants (N=8) consisting of five females (N=5) and three males (N=3) volunteered to take part. The sample consisted of lecturers and both research and clinical Masters degree students in the psychology department at the University of South Africa (UNISA).

One requirement to partake in the study was that the volunteer should have held a legal driver's licence for a minimum period of two years. The average length of license ownership was 14,6 years. The two-year restriction was deduced from a study conducted by Boer et al. (2006) who conclude that the novelty effect with regard to driving will have worn off after a period of two years. Based on this restriction some potential volunteers had to be rejected because they did not fulfil this requirement. Ultimately however, all of the participants that took part in the study were in the possession of a valid South African driver's licence.

Another requirement was that participants should preferably not have had any prior experience with a Playstation 3. The reason for this is that a participant with experience would perform better than those without it; the results from such an analysis would be inconsistent and, in this case, misrepresent the relationship between the tempo of music and a driver's concentration and ability to drive.

The sample was obtained by sending out emails to individuals in the Department of Psychology at UNISA, requesting that any person willing to partake in the study should contact the researcher. The first response was poor and therefore the emails were resent in an attempt to obtain more volunteers. Again, an insufficient number of people responded and thus individuals in the department were personally approached and asked whether they would be willing to volunteer; one participant heard about the study by word of mouth and volunteered without being approached.

Initially, ten volunteers were recruited of which six were female and four were male. It was decided to include at least ten participants. However, one female participant withdrew for personal reasons after completing the NM control condition and one male participant's scores were regarded as invalid as he was found to have extensive Playstation experience. Because a convenience sample was employed, and because of the difficulty experienced in recruiting participants, there was no control over the gender of the participants.

3.4.1 Descriptive information of the sample employed

The reason for selecting individuals affiliated with the University of South Africa for participating in the study was that this produced a sample that was reasonably homogeneous in nature due to their educational background. All of the individuals who volunteered to partake have met the predetermined requirements which in itself provided homogeneity between the respective participants in the sample. The only difference between these volunteers was the amount of driving experience determined by how long they have been driving which was not regarded as relevant due to each of the participants meeting the requirements. The mean age across all participants (N=8) was 38.375 years.

Table 3.1: *Description of the participants in the sample*

Participant	Age	Gender	Race	Total amount of driving experience in years	Year in which licence was obtained
1	48	Female	Caucasian	16 years	1994
2	34	Female	Caucasian	16 years	1994
3	25	Male	Caucasian	6 years	2004
4	37	Female	Caucasian	9 years	1991
5	58	Male	Caucasian	30 years	1970
6	23	Female	Caucasian	5 years	2005
7	38	Female	Black	9 years	2001
8	44	Male	Caucasian	26 years	1984

Table 3.1 provides an indication of the eight (N=8) participants who partook in the study. The information presented in the table above specifies the age, gender and race of the participants as well as the year in which they received their driver's licence.

Because only a convenience sample was utilised and because of the pre-requirement relating to driving experience, the sample is not representative of the existing cultural diversity in South Africa.

3.5 WEAKNESSES & STRENGTHS OF THE RESEARCH DESIGN

3.5.1 Weaknesses of the research design

Forzano and Gravetter (2006) state that there are some limitations with regard to the use of a convenience sample, all of which could have an influence on the validity of the research study. These include the possibility of a biased and unrepresentative sample group because there is no selection process used for obtaining a convenience sample. The sample may therefore not be representative of the general population. This limits the generalisability of the sample, while other problems with the application of the results could possibly be experienced. A homogenous sample is important as it ensures that the participants are of equal status, which is important for the performance outcome expected in the study's results. In an attempt to keep the sample for this study as homogenous as possible, only individuals within the institution of UNISA were accepted as volunteers.

Another limitation pertaining to the study is related to the sample size. It is not ideal to employ a sample which includes only eight participants when conducting a quasi-experimental study. However, each participant was introduced to four respective treatment conditions, as mentioned, which means that a total of 32 group means were available for statistical analysis.

Several musical elements were excluded from the study which may also influence concentration and behaviour while driving; these include volume, intensity, duration, vocals or instrumentals and language usage. Another factor which may have influenced the results is that the participants were “driving” in a non-natural setting; thus there was an absence of a motor vehicle, there were no other vehicles in the vicinity and there was no traffic or noises associated therewith. This may have given an unnatural feeling to the study which has the possibility of influencing the results negatively.

Hargreaves and North (2008) indicate that certain problems exist in the attempt to investigate music and psychology. The problems experienced in this study relate to the measuring of the participants’ behaviour elicited by the presence of music. Thus, creating an appropriate quasi-experimental design together with the appropriate treatment conditions in which adequate behaviour can be elicited, requires careful planning and execution. Also, the massive variety of music available means that deciding which element of music to investigate and which type of music to include, was difficult. Much thought was given with regard to which tracks would serve the purpose of eliciting the appropriate reactions and behaviours for this investigation.

3.5.2 Strengths of the research design

Together with the negative elements inherent in the utilisation of a convenience sample, there are also positive elements which should be mentioned; expenses are much less, participants are easier to recruit and the process of collecting a sample is less time consuming (Forzano & Gravetter, 2006).

A naturalistic study is known to provide more realistic and accurate results and would be applicable here if a real driving context was utilised. However, there are certain advantages to conducting an experimental study in a laboratory setting, namely that a researcher has control over the experimental stimuli (Hargreaves & North, 2008). One method of control utilised in this study was the pre-selection of music that was utilised in each treatment condition (NM, LTM, MTM and HTM). Although the participants may have heard some of the selected music prior to the study, they were not informed of these choices prior to their participation in the study. With this precautionary measure in place, it was assumed that the music selected did not have an influence on any of the participants' responses.

According to Hargreaves & North (2008), another benefit of an experimental study is that it can control for participants' responses and behaviour brought on by external factors. External factors concerning the study included weather and traffic conditions, and road infrastructure. For this reason the study was conducted in a laboratory-like setting to ensure that control over external variables was maintained.

3.6 MEASURING INSTRUMENTS

Participants were tested in a venue located at UNISA which was made available by the Department of Psychology. A Playstation 3 was situated within the venue on which the driving simulation game, *Gran Turismo 5 Prologue Spec II*, was played. This console game is generally assumed to be the most realistic driving simulation game on the commercial market. A 23 inch Samsung high-definition monitor was used for the display of the driving simulation game. A Logic3 Tri-format Top Drive GT steering wheel with pedals was used for the purpose of simulating, as realistically as possible, the effect of real-life driving. Pre-selected music was played via an Acer

Aspire 5610Z laptop on a Wharfedale WH-FP525 sound system. The volume was standardised within a range of 70-80dB by making use of a Brüel and Kjaer 2205 sound-level meter. Participants completed the study in a Suzuki Cappuccino, which was the pre-selected vehicle, with automatic transmission. The track used in the practice session was the Daytona race track, while the one employed for the actual study, under the four respective music treatment conditions, was the London race track.

Participants were placed behind a steering wheel and pedals which they could adjust until they were seated comfortably. Furthermore, an animated steering wheel on the monitor rotated in accordance with the steering wheel that the participants manually rotated. The display also presented the participants with an in-car view, which showed a speedometer and a rear-view mirror. On the monitor participants were presented with a blue line that indicated the best position on the track in order to make the turns successfully.

3.6.1 Classification of music

In order to obtain a distinction between the different proposed conditions in the study, the classification of music into groups, based solely on tempo, was necessary. Brodsky (2002) indicated that HTM is any music above 120 BPM whereas LTM is any music below 60 BPM. Based on this, the conclusion was drawn that any music measuring between 60BPM and 120 BPM could be classified as MTM.

Moon (2010) stated that there is no set rule relating to the classification of music and within the context of music and the categories of low, medium and high intensity music, there appears to be a lack of information. However, the categorisation method of tempo as discussed by Brodsky (2002) was used as a guideline to determine the different music treatment conditions.

Music was selected by the researcher in order to standardise the research setting and so that the participants' preferences had no bearing on their level of concentration and driving behaviour.

The music was obtained from Dj BPM Studio.com (2008) which has a wide range of music available (a database of 72,192 tracks). The music selected for the purpose of this study was chosen at random from a list of songs which displayed their respective BPM. The music was selected in such a manner that a wide variety of tempos were included. This means that in each of the treatment conditions, music corresponding to that tempo could be chosen exactly. The BPM of each song could not be individually measured due to inconsistencies across different programmes utilised for this purpose.

As mentioned, the focus of the study falls on tempo which is a measure of the speed or rhythm of music (Dj BPM Studio, 2008). Therefore, all other elements, which include intensity, volume, vocals, instruments and genre, were disregarded. It is understood that these elements may also have an effect on a driver's concentration and driving ability; however, the reason for disregarding them is that, for the purposes of this study, the effects of a single element (tempo) needed to be identified and investigated.

3.6.2 Randomisation of the treatment conditions and the purpose thereof

It was anticipated that playing the pre-selected music in a specific order from the NM control condition to the HTM treatment condition could cause a practice effect to occur which is known to result in an improvement in performance. Results obtained in such an instance are assumed to be unrepresentative of true behaviour as it is unknown whether the responses elicited were due to the relationship between the tempo of music, concentration and driving behaviour, or due to practice effects (Forzano & Gravetter, 2006). In order to prevent this from occurring, treatment conditions were provided in a random order. For each participant, the NM control condition was presented first as it served as a baseline which could be scored and observed as their 'normal driving behaviour'. Thereafter, each participant was presented with the treatment conditions in a random order.

Randomisation of the treatment conditions was conducted by means of a randomised number list. The researcher created all of the possible combinations for the three treatment conditions; that is LTM, MTM and HTM, and assigned participants to a specific combination randomly on the day of the study.

The following table illustrates the selected music employed in the research study:

Table 3.2: *Pre-selected music applied to each respective treatment condition in the study*

Artist	Genre	Album	Song	BPM	Tempo
One Republic	Pop/Rock	Dreaming Out Loud	Apologize	29.53	LTM
Avril Lavigne	Rock/Pop	The Best Damn Thing	When You're Gone	35.50	LTM
Fergie	Pop/Rap/Hip-Hop	The Dutchess	Big Girls Don't Cry	56.56	LTM
Lenny Kravitz	Rock/Pop	Baptism	Calling All Angels	59.48	LTM
Fergie	Pop/Rap/Hip-Hop	The Dutchess	Fergalicious	64.50	MTM
Billy Talent	Rock/Pop	Billy Talent II	Perfect World	82.51	MTM
Evanescence	Rock/Pop	Anywhere But Home	Taking Over Me	90.01	MTM
Linkin Park	Hard Rock & Metal/Pop	Meteora	Breaking The Habit	100.5	MTM
Timbaland	Pop/Rap/Hip-Hop	Shock Value	Micommuniation (ft. Keri Hilson & Sebastian)	106.6	MTM
Nickleback	Rock/Pop	Dark Horse	Something In	130.00	HTM

			Your Mouth		
Linkin Park	Hard Rock & Metal/Pop	Minutes to Midnight	Bleed It Out	140.06	HTM
Black Eyed Peas	Rap & Hip-Hop/Dance & DJ	Monkey Business	Pump It	153.56	HTM
Billy Talent	Rock/Pop	Billy Talent II	This Suffering	163.01	HTM
Fall Out Boy	Rock/Pop	Infinity On High	Don't You Know Who I Think I Am?	163.01	HTM

(Dj BPM Studio, 2008).

3.7 STANDARDISATION OF THE STUDY

3.7.1 Standardisation of the research setting

In order to ensure standardisation of the study, it was conducted in the same venue for every participant. The layout and set-up of the equipment were consistent throughout the study and the instructions were presented in the same manner every time. There was no interference from the researcher when the study started; however, participants were allowed and encouraged to ask as many questions as possible and to express any concerns they may have had before the study began. These questions and concerns were addressed before the participants were allowed to start the NM control condition, and observation and scoring began.

Participants were not allowed to select or bring their personal choice of music as this could have been detrimental to the standardisation of the study. However, by pre-selecting certain types and genres of music, there is a risk that participants may have taken a potential dislike to the pre-selected music.

3.7.2 Standardisation of volume

Volume was not included as a variable to be investigated in this study. However, the purpose of standardising the volume of the music in each condition is to exclude volume as a possible element of distraction. The volume of the music in the study was standardised between 70dB and 80dB to ensure that participants were aware of the presence of music but not to such an extent that they might suffer from hearing loss.

When one is driving on the road with one's windows down and the radio turned off, the sound level experienced is said to be approximately 70dB (It's your health, 2010). Listening to music at levels of 85dB presents no known health risks. However, when exposed to music of this volume or louder for more than eight hours, health risks are a definite possibility (It's your health, 2010). The volume of music may have a detrimental effect on hearing if it is too loud. Boyle and Radocy (2003) state that exposure to loud sounds on a continuous basis may endanger hearing. In-vehicle music typically fulfils a background function and is not the main focus of awareness.

3.8 PROCEDURE IN OBTAINING DATA

For the purpose of investigating the effect of different tempos of music on concentration and driving ability, four music conditions were employed. The NM control condition served the purpose of establishing a baseline for each participant. Thereafter, the three remaining music treatment conditions were randomised for each participant in order to counteract practice effects. The task that each participant was required to do remained exactly the same in all four conditions throughout the entire study. All of the participants (N=8) completed their task in all four treatment conditions; this is known as a within-subject quasi-experimental design (Forzano & Gravetter, 2006). After the results were obtained, comparisons were drawn between the four treatment conditions in order to determine the differences or similarities between each of them.

DE made while completing the study were illustrated by deviations from the blue line on the monitor and provided an indication of concentration and how it is influenced by the music employed in each treatment condition.

Thus the question remains: does the tempo of music have an influence on concentration? H1 is the aim of investigation at this point. This component of behaviour is thus postulated to be the availability of mental resources for the purpose of performing multiple tasks simultaneously. Thus, it is postulated that HTM will lead to an increase in the amount of DE and that there will be a decrease in DE when a participant is exposed to LTM. This is postulated to occur due to the assumption that HTM will use more mental resources in comparison to LTM and MTM. This in turn results in fewer mental resources being available for other incoming information and the processing thereof. This is the task of H2: to investigate whether HTM has a bigger influence on concentration in comparison to NM, LTM or MTM.

Driving behaviour was observed and recorded by means of lap-times (LT) and analysed to determine the effect of music on driving ability and performance. The purpose of LT, representative of driving behaviour, aimed to establish whether, as stated in H3, the tempo of music has an influence on driving behaviour. This was determined by the physical observation and recording of each participant's behaviour. These results are directly related to the type of music each participant was exposed to in the different music treatment conditions.

In order to maintain a high standard of practice, each participant had to read and sign a consent form in which complete instructions were provided (Appendix A). Each participant then completed a questionnaire which served the purpose of: collecting background information; music preferences; information regarding the normal conditions under which they listen to music while driving; the mood that they were in on the day of the study; and whether they followed the instructions given to them before the day of the study to have a good night's rest (see Appendix C).

After completing the questionnaire, the participants were provided with the opportunity to complete a twenty-minute practice session in which they drove on a circular track to familiarise themselves with the equipment and to practise remaining on the blue line. Participants were also informed of the eighty kilometres per hour speed limit set by the study. As the chosen track included numerous sharp turns, it was foreseen that participants might struggle to remain on the blue line while completing these turns. Thus a speed limit was set. The participants were required to have no Playstation 3 experience and thus it was anticipated that the difficulty of the task would be high.

After successfully completing the practice session, participants were allowed to start with the study. Each participant was first presented with the NM control condition for the purpose of establishing a baseline in performance, concentration and deviation from the blue line (DE). For the remaining three conditions (LTM, MTM and HTM), all of which were randomised from one participant to another, the same task applied.

The task was to complete a lap as fast as possible, while remaining on the blue line. It was emphasised that remaining on the blue line was more important than speed, meaning that participants were required to be more accurate than fast. The reason for this is based on the assumption that the blue line is representative of concentration; any deviation from that line for longer than five seconds (during which they have the opportunity to correct their error) is postulated to be an indication that music has had an influence on that participant's concentration. If five seconds were exceeded, this time was included in the total time that it took a participant to correct their error. Participants were thereby forced to divide their attentional resources between two factors; the road and the computer monitor (Bauer, 2009).

A number of psychomotor abilities such as coordination and reaction time to mention a few can be obtained from such a study provided that adequate and sufficient equipment are available. However, for the purpose of this study the researcher specifically wanted to focus on concentration as the main point of investigation in an environment that closely resembles that of a natural driving context possible and therefore the utilisation of a simulated driving context. In this document it has been acknowledged that there could be alternative causes for the results that were obtained, however the focus of this study remains on concentration and its influence on driving ability in a driving specific context.

The participants were exposed to the four treatment conditions for a duration of fifteen minutes each. Other than their first lap, incomplete LTs were not recorded for the purpose of statistical analysis. This is simply because distance could not be recorded, and thus an incomplete LT could not provide any useful information.

3.8.1 How lap times, errors and additional behaviour were recorded

LTs were recorded as participants completed one lap and continued with the next. The LTs for each treatment condition were added up and then converted back to seconds in order to conduct a statistical analysis. DE times were recorded with a stopwatch that started timing as participants deviated from the blue line; if that amount of time was below the cut-off of five seconds, the stopwatch was reset. However, if that time exceeded the cut-off, the timing continued until the participant succeeded in returning to the blue line. A raw score for DE was obtained for each treatment condition by adding up the total amount of errors made and converting that time, if minutes, back into seconds. Furthermore, informal observations were made simultaneously on behaviour elicited and comments made by the participants.

3.9 RELIABILITY & VALIDITY

3.9.1 Reliability

The study was conducted on a Playstation 3 console gaming system as discussed earlier. This study was partly adapted from previous studies conducted by Brodsky (2002) and Boer et al. (2006). Brodsky (2002) included the use of a computer on which participants had to complete a pre-determined lap. Boer et al. (2006) on the other hand required participants to familiarise themselves with the ‘vehicle’ in a simulation context and also complete a practice session. The study presented in this document firstly employed some ideas from the study of Boer et al. (2006). Each participant had to complete a practice session in which they were accorded the opportunity to familiarise themselves with the ‘vehicle’ and the manner of ‘driving’. Then Brodsky’s concept was employed with regard to completing a pre-determined lap in the presence of different tempos of music, where each treatment condition included a pre-determined time limit (2002). This study was therefore created by extracting and employing different methods from different studies, all of which obtained significant results.

Furthermore, a social science statistician was employed to assist with conducting all of the statistical analysis. This was done in order to increase the reliability of the results and ensures that the results presented in Chapter Four were analysed thoroughly and accurately.

3.9.2 Postulated problems with regards to reliability

When conducting a measurement, an observed score is obtained based on the individual behaviours relating to the dependent variable. The observed score is divided into two components; the true score and measurement error. The former refers to the trait that is observed and the actual degree of performance of that trait. The latter includes any other factors not included for investigation. However, because of imperfections inadvertently included in a study, they tend to enter into the variables that are not accounted for. Thus they influence the results obtained (Whitley, 2002). Systematic errors are said to be ever-present when each measurement is scored; "As a result, the observed score is stable, but inaccurate as an indicator of the true score" (Whitley, 2002, p. 125). This is assumed to be caused by an instrument that measures not only the intended trait, but also other traits which were not included for the purpose of the investigation.

Measurement error with regard to this study refers to an observed score that is used for obtaining scores for statistical analysis. Due to human error, it was acknowledged that some inaccuracies may have occurred during the observation and recording of each participant in each of the treatment conditions. This was accounted for by recording each participant, exposed to each condition, entirely. If necessary, those conditions could be rescored again. The purpose for the option of rescoring each of the treatment conditions is to provide the opportunity to confirm lap-times if required to do so in order to ensure accurate results for analysis purposes. This is based on the researcher conducting the research process alone and it thus acts as a supportive and confirmation process if the need arises. Also accounted for were other factors that could cause variations in the results. These factors include fatigue, emotional health and well-being, and a novelty effect which were discussed in detail earlier in this chapter.

3.9.3 Validity

Confirmation of validity could support a cause-effect relationship between the tempo of music and a driver's concentration and driving behaviour (Forzano & Gravetter, 2006). The aim of the study was to determine whether measured driving performance is a function of treatment condition, and more specifically, that HTM will have a significantly bigger influence on concentration than LTM or MTM.

Furthermore, validity theoretically refers to how well something measures what it claims to measure (Foxcroft & Roodt, 2005). The study is based on a simulation of driving, and does not investigate a real-life driving context which would have been optimal in obtaining results. However, since simulation was the only feasible option, provisions were made to simulate the effect of driving as closely as possible by means of the technological equipment utilised. Participants were thus exposed to a research setting that recreated reality as closely as possible in an attempt to obtain results that would be reflective of a real-life context.

Because the study simulated the effect of driving as accurately as possible, it is assumed that the behaviour observed is reflective of the behaviour in a real-life driving context. Even with the loss of extraneous factors such as traffic and weather conditions, results are still assumed to have measured concentration and driving ability as they would exist under normal driving conditions.

Validity measures applied to the study include face validity which means that all of the results obtained and behavioural observations made, have been recorded by the researcher. Although this form of validity is easy to obtain, it is said to be unquantifiable and one cannot measure it scientifically (Forzano & Gravetter, 2006). Thus face validity is regarded as very subjective in nature and prone to human error, such as the researcher making inferences during the course of the study.

Content validity refers not only to concentration as the trait being assessed, but also to driving ability. Concentration is proposed to be represented by the DE made by each participant when deviating from the blue line. It is assumed that the task of having to remain on the blue line requires that participants concentrate in order to complete that task successfully. Based on this assumption it, is further postulated that any deviation from this line is indicative of a lack of concentration on the task at hand, and that this is due to the specific tempo of the music employed for that condition. Driving ability as a trait is measured in speed, which is said to reflect driving behaviour. The assumption is made that the tempo of the music in the car influences the driver's behaviour and thus the speed at which they drive.

3.10 ETHICAL CONSIDERATIONS

No ethical issues were foreseen to affect the participants of the study because of the simulation methodology employed. Thus participants were not exposed to the risks involved with conducting a study on the national roads. Participants were also informed that if they did not feel comfortable with their involvement in the study, that they could stop the study at any point and could withdraw if they pleased.

Participants were furthermore assured of their anonymity and that their results would be used for statistical purposes only. Since there were no known emotional factors related to the study, no in-depth personal and emotional information had to be disclosed by any of the participants in order to participate. In correspondence with good practice, each participant was informed in detail of the processes involved within the study. Their signature was also required to indicate their acknowledgement of the processes involved and their confirmation that they were taking part on a voluntary basis. Furthermore, each participant was formally presented with a complete set of instructions (Appendix A, B & C).

Chapter Four will provide an in-depth discussion of the results that were obtained after statistical analysis was conducted.

CHAPTER 4:

RESULTS

4.1 INTRODUCTION

This chapter provides a rationale for the techniques used for the statistical analysis. In addition, all of the results obtained by means of statistical analysis are presented and are then followed by an explanation.

Statistical analysis was conducted on the data collected during the study using the SAS JMP 8.0 statistical package. Because of the limited number of participants (N=8), a preliminary exploration was first carried out to establish whether the data fitted a normal distribution. This was to determine whether parametric techniques could be used for the statistical analysis. As shown in figures 4.1 and 4.2, the data was normally distributed (approximately) and parametric methods were therefore deemed to be suitable.

In the study, differences between the mean scores in the four different treatment conditions were determined from a single sample. Thus, a repeated measure, ANOVA, was considered to be the most appropriate statistical technique to apply. An ANOVA is used when a relationship exists between more than one independent variable and a dependent variable, or where an independent variable has several levels and the effect of each of these levels on the dependent variable needs to be investigated (Field, 2005).

The independent variable of the study was ‘music tempo’, which comprises four different conditions (levels), described earlier. Two different dependent variables were identified and utilised in two separate analyses; ‘concentration’ and ‘driving ability’.

A lapse in concentration in the study was associated with deviation recorded from the blue line presented on the monitor. Because participants were briefed on the importance of remaining on the blue line, it was postulated that any deviation from this line was a result of a decrease in concentration due to the presence of music. Driving ability was determined by means of the speed with which participants completed the LT. Also related to driving ability was the physical behaviour elicited by participants in the presence of different musical tempos. A detailed description for the measuring of concentration and driving ability is furnished in Chapter 3.

Concentration refers to the “capacity for sustaining attention to a particular stimulus or activity” as defined by Shaffer (2002, p. G-1) and was measured in terms of a participant’s ability to perform the task of simulated driving while in the presence of different musical tempos as specified above. Driving ability on the other hand was postulated to be represented by speed, indicated by LT in the study. Driving ability was ascribed to the behaviour that individuals would elicit under normal circumstances while in a driving context, and the way in which it is influenced by the presence of music.

The repeated-measures design derives its name from the fact that each participant provides repeated scores on the response variable. In this study, every participant was exposed to all four treatment conditions of the independent variable and a response score was obtained for each participant under each of these conditions.

Field (2005) says that the standard deviation provides an indication of the shape of the distribution based on the obtained results. Standard deviation thus indicates the deviation from the mean, so that the bigger the standard deviation, the wider the spread between the results (Pretorius, 2007). It can therefore be concluded that the bigger the variance in the standard deviation, the greater the chances are for error in the accuracy of the results.

Alpha level, also referred to as the level of significance, is used to determine whether the results can be attributed to chance (Forzano & Gravetter, 2006). In the study, an alpha level of 0,05 was used in the statistical analysis. The purpose of determining this level is to determine whether the results obtained from the sample were due to chance or whether there is, in fact, an existing relationship between the tempo of music and concentration and driving ability. Thus, if the results indicate that error is accounted for by more than 5%, it can be concluded that those results are based on chance. The opposite would also be true; if DE is accounted for by less than 5%, it can be concluded with a 95% level of confidence that the results were not due to chance.

4.2 STATISTICAL RESULTS OBTAINED FROM DATA

4.2.1 Testing of normality

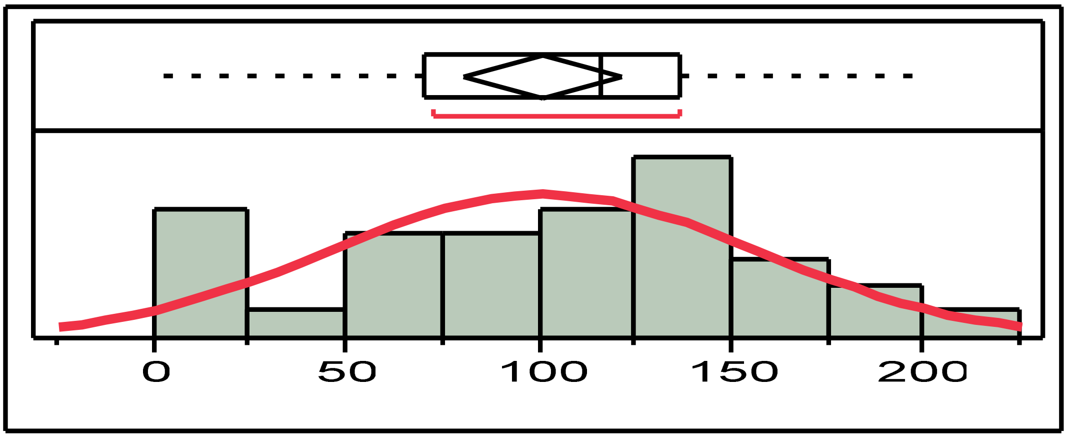

Fig. 4.1: *Graphical illustration of the distribution of normality for driving errors*

The assumption of normality was tested. The results obtained from the Shapiro Wilk test indicated that the data and results obtained were also normally distributed for the observed errors. A normal distribution such as the one obtained above indicates that the majority of the participants obtained scores situated in the middle range in terms of DE, with the exception of a few participants who increasingly made more mistakes, and others who made no mistakes at all.

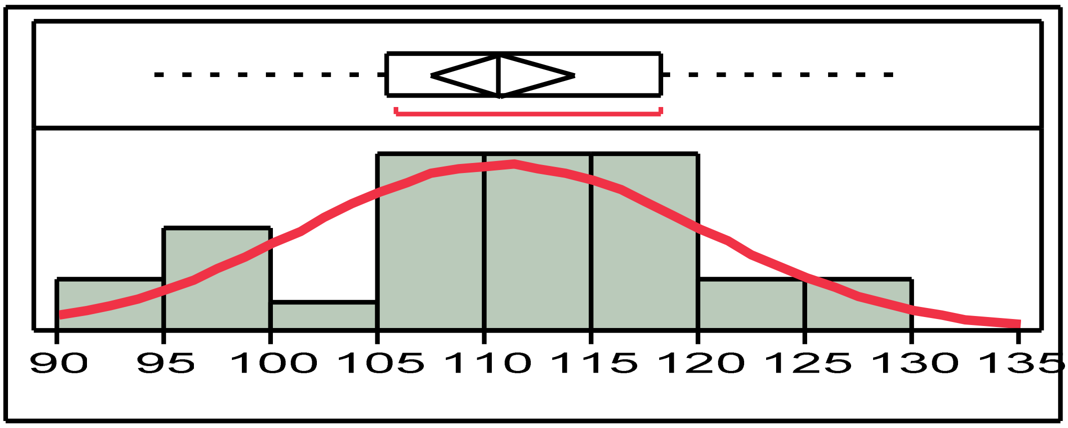

Fig. 4.2: *Graphical illustration of the distribution of normality for lap-times*

Again, the assumption of normality was tested using the Shapiro Wilk test, which indicated that the data and results obtained were normally distributed for LT. A normal distribution such as the one obtained above indicates that the majority of the participants obtained scores situated in the middle range with regard to speed, with the exception of a few participants who completed LT at a slower or faster pace.

Concerns regarding the normal distribution of the results were discussed in the introduction at the beginning of this chapter. Figure 4.1 and Figure 4.2 illustrate graphically that the distribution of the data is relatively normal. These graphs thus indicate that concerns about normality were irrelevant and parametric statistical methods were employed for the remainder of the analysis to be conducted on data for both DE and LT.

4.2.2 Statistical results obtained for driving errors

Table 4.1: *Significance indicators for driving errors indicative of concentration*

Source	SS	DF	MS	F Ratio	Prob>F
Whole Model	67907.1	10	6790.710	4.816	0.0012*
Treatment	6767.7	3	2255.888	1.600	0.2193
Participant	61139.4	7	8734.205	6.195	0.0005*
Errors	29607.7	21	1409.892	.	.
Observed Interaction	29607.7	21	1409.892	.	.
Error2	-7.28e-12	0	.	.	.

Table 4.2: *One-way ANOVA significance indicator for driving errors indicative of concentration*

Source	SS	DF	MS	F Ratio	Prob>F
Between Participants		7			
Within Subjects	36375.4	24	1515.64	1.075	
Treatment	6767.7	3	2255.89	1.6	0.2193
Residual	29607.7	21	1409.89	.	.

Results were analysed using a one-way analysis of variance (ANOVA) repeated-measures design which revealed an insignificant effect for the treatment, with $F(3,21)=1.6$ and $p=0.2193$. This suggests that the tempo did not have a causal effect on the larger amount of DE in the MTM and HTM treatment conditions, and that these findings can be attributed to individual differences as indicated in Table 4.1. order effects were not considered to influence the results as the conditions were randomised for each participant.

The results shown in Table 4.1 thus seem to suggest that DE should not be regarded as the reason for the decrease in concentration while driving as stated in H1, but should rather be attributed to the individual characteristics (p=0.0005) of each participant. In simpler terms, the tempo of music was not found to influence concentration while driving.

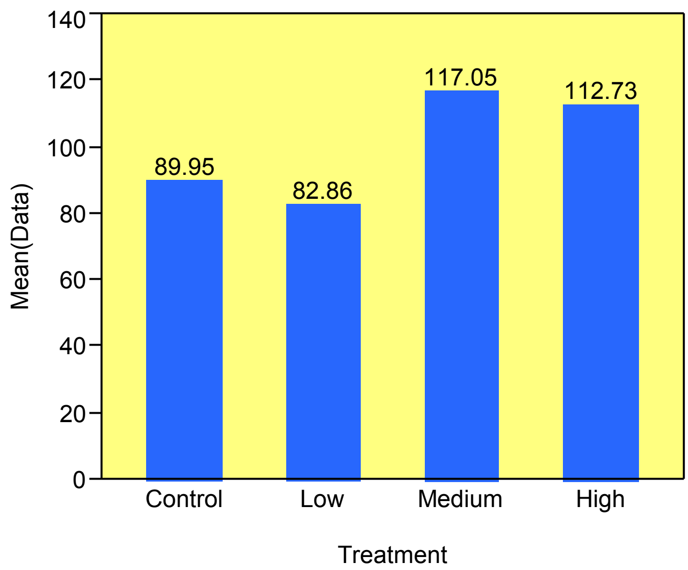

Fig 4.3: *Driving errors made in each respective treatment condition*

Figure 4.3 presents a graphical illustration of the results obtained for DE. Participants were instructed to remain on the blue line, and any deviation from this line for five seconds or longer was recorded. This sought to determine the amount of DE made in each respective treatment condition. The amount of DE that occurred was regarded as being an indicator of the influence that the tempo of music has on concentration.

The results are presented as mean data which was calculated by converting DE times back to seconds; after this, all of the participants' (N=8) results were averaged. It is evident from the graph that most of the errors occurred in the MTM treatment condition (117.05) followed by the HTM treatment condition (112.73). Significantly, fewer DE were observed in the NM control condition (89.95) and the LTM treatment condition (82.86). Results obtained in this graph do not provide supporting evidence for H2, which states that the majority of the DE will occur in the HTM treatment condition.

Table 4.3: *Statistical results for driving errors*

Treatment	N Rows	Mean(Data)	Std Dev(Data)	Min(Data)	Max(Data)
Control	8	89.95	68.58224	0	182.35
Low	8	82.8575	40.68173	0	128.14
Medium	8	117.0475	65.3357	0	201.13
High	8	112.7338	48.3384	0	152.02

The mean results in Table 4.3 indicate that there is a vast difference between the DE in the NM control condition (89.95) and the LTM (82.86), MTM (117.05) and HTM (112.73) treatment conditions.

Table 4.3 further indicates large variations in the standard deviations obtained in all four treatment conditions. The largest standard deviation obtained was in the NM control condition (68.58) followed by the MTM treatment condition (65.34). Although standard deviations are lower in the LTM treatment condition (40.68) and HTM treatment condition (48.34), this still provides supporting evidence against H1, which states that the tempo of music will have an influence on concentration while driving.

The minimum and maximum data for each condition gives an indication of the amount of DE made by all participants, ranging from the least to the most DE observed and recorded. The minimum DE observed was zero, based on one participant who managed to complete three of the treatment conditions without deviating from the blue line for more than five seconds.

Thus, the results indicate that the tempo of music does not influence concentration as originally proposed in H1. In turn, the results imply that HTM does not have a greater influence on concentration in comparison to the NM control condition, and the LTM and MTM treatment conditions as stated in H2.

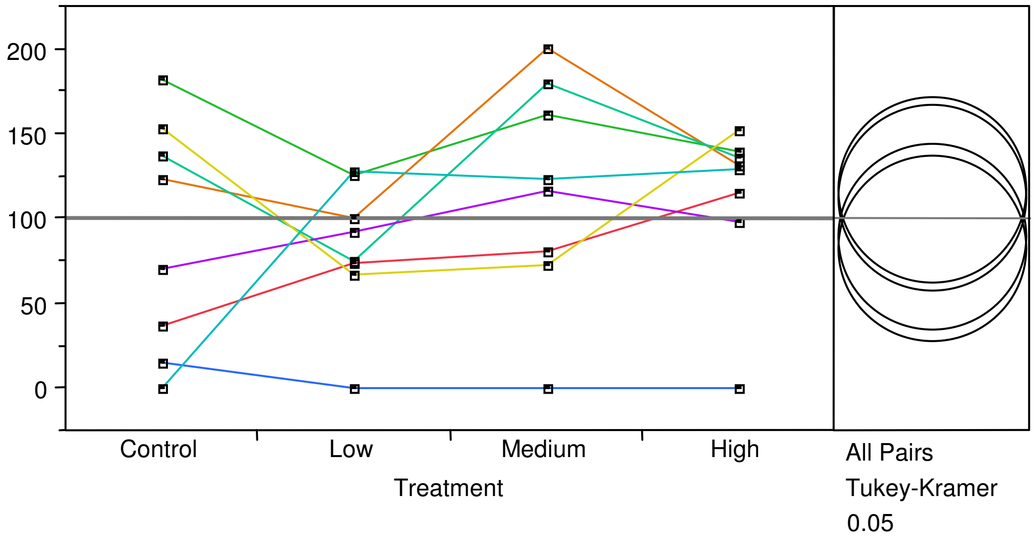

Fig. 4.4: *Individual performance of each participant across all four treatment conditions indicated by driving errors*

In general, the errors recorded and observed indicate a similarity in performance between the no-music treatment condition and the medium tempo music condition. The same appears to be true for the low and high tempo music treatment conditions. Thus, the observed errors did not occur as expected in that they did not increase systematically with the tempo of music.

Figure 4.4 provides insight into each individual participant's performance across all four conditions. It appears as though the majority of participants made fewer errors in the NM control condition than in the LTM treatment condition, except for three participants represented by the red, purple and turquoise lines. Errors in general increased from the LTM to MTM treatment conditions, except for the participant represented by the dark blue line whose errors remained constant across the three music treatment conditions. An interesting observation is that, except for the participants represented by the gold and red lines, the number of errors made between the MTM and HTM treatment conditions decreased. Figure 4.4 graphically illustrates that the most DE was recorded in the MTM treatment condition.

Table 4.4: *Means comparisons between treatment conditions for driving errors*

	q*	Alpha
	2.73031	0.05

Abs(Dif)-LSD	**Medium**	**High**	**Control**	**Low**
Medium	-77.7177	-73.4039	-50.6202	-43.5277
High	-73.4039	-77.7177	-54.9339	-47.8414
Control	-50.6202	-54.9339	-77.7177	-70.6252
Low	-43.5277	-47.8414	-70.6252	-77.7177

Positive values show pairs of means that are significantly different.

After conducting an ANOVA statistical analysis, a post-hoc test was required in order to determine which groups in the study differ from one another (Field, 2005). In Table 4.4 there were no significant differences between the mean comparisons for the NM control condition, and the LTM, MTM and HTM treatment conditions. Only positive values are said to be indicative of significant difference.

4.2.3 Statistical results obtained for lap-times

Table 4.5: *Significance indicators for lap-times indicative of driving behaviour*

Source	SS	DF	MS	F Ratio	Prob>F
Whole Model	2121.706	10	212.1706	6.708	0.0001*
Treatment	976.974	3	325.6581	10.296	0.0002*
Participant	1144.731	7	163.5330	5.170	0.0015*
Errors	664.241	21	31.6305	.	.
Observed					
Interaction	664.241	21	31.6305	.	.
Error2	1.12e-12	0	.	.	.

Table 4.6: *One-way ANOVA significance indicator for lap-times indicative of driving behaviour*

Source	SS	DF	MS	F Ratio	Prob>F
Between		7			
Participants					
Within Subjects	1641.21	24	68.38	2.16	
Treatment	976.97	3	325.66	10.30	0.0002*
Residual	664.24	21	31.63	.	.

The experimental results were analysed using a one-way analysis of variance (ANOVA) repeated-measures design which revealed a significant effect for the treatment, with $F(3,21)=10.296$ and $p=0.0002$* at a 95% level of confidence. A significant effect for the participants, with $F(7,21)=5.170$ and $p=0.0015$* at a 95%

level of confidence, was also detected. Order effects were not considered to have an influence on the results as the treatment conditions were randomised. Table 4.5 shows supporting evidence that the tempo of music does have an influence on concentration as stated in H3.

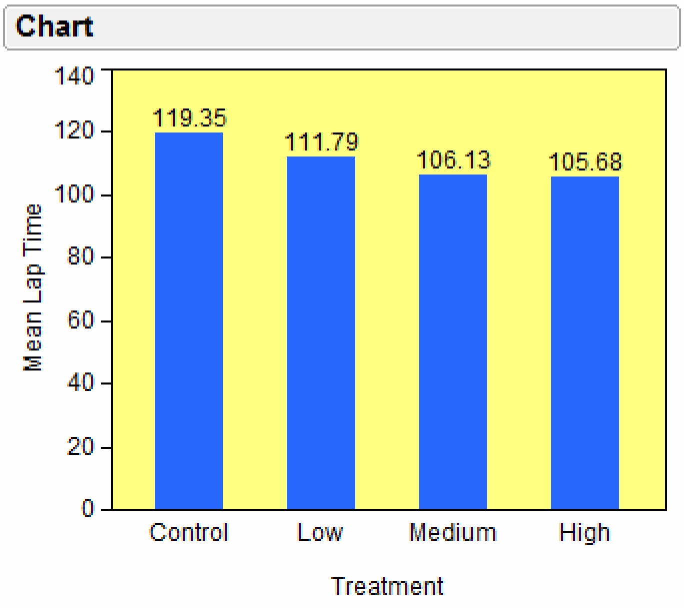

Fig. 4.5: *Lap-times recorded in each respective treatment condition*

Figure 4.5 graphically illustrates how the speed at which the participants completed the laps systematically increased as the tempo of music increased. The results are indicative of a graph that is slightly positively skewed. This graph furthermore presents confirmatory evidence that the tempo of music has a direct influence on driving behaviour due to the decrease in LT as the treatment conditions increase in tempo.

Table 4.7: *Inferential statistical results for lap-times*

Treatment	N Rows	Mean(Data)	Std Dev(Data)	Min(Data)	Max(Data)
Control	8	119.3522	7.400767	106.92	129.935
Low Tempo	8	111.7923	11.75865	94.04444	123.6257
Medium Tempo	8	106.1274	5.362741	97.11333	110.8438
High Tempo	8	105.6835	6.052156	94.02556	111.0713

The mean data obtained in Table 4.7 provides an indication of the average score representing the recorded lap times for all participants (N=8). The NM control group (119.35) is significantly different to the mean data obtained for the HTM treatment condition (105.13). There appears to be no difference between the MTM treatment condition (106.13) and the HTM treatment condition. Mean results indicate a decrease in LT for all of the participants (N=8) as the tempo of music increased.

Standard deviations indicated in Table 4.7 are relatively small with the largest standard deviation obtained in the LTM treatment condition (11.76). The NM control condition (7.04) and MTM (5.36) and HTM treatment condition (6.05) all indicate relatively small standard deviations, and the results all fall within a small range of one another, thereby indicating no real difference in the effects of different musical tempos. This means that the results obtained allow for tentative assumptions to be drawn based on the sample utilised (N=8), concluding that the tempo of music has an influence on driving behaviour as stated in H3. Minimum and maximum data provides an indication of the fastest and slowest LT, averaged for all of the participants for a specific treatment condition, in seconds.

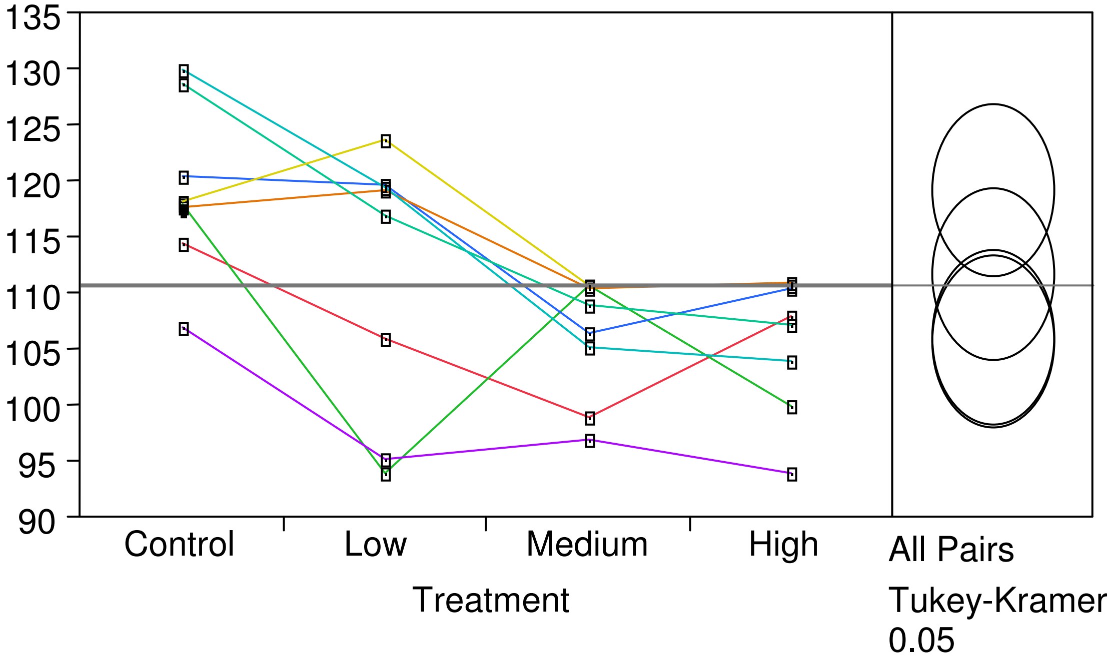

Fig. 4.6: *Individual performance of each participant across all four treatment conditions indicated by lap-times*

Figure 4.6 illustrates each individual's performance in all four respective treatment conditions. Each participant is represented by a differently coloured line.

The participant represented by the purple line has managed to complete all four conditions at a relatively fast pace as the time indicates a quick LT in comparison with the remaining seven participants. Other participants' LTs appear to vary across each treatment condition, as shown by the participants represented by the gold, blue and pink lines. The participants represented by the light blue and turquoise lines started off slowly with the NM control condition, while the speed with which they completed the laps increased significantly as a result of the different music conditions. The participant represented by the green line completed laps in the LTM and HTM treatment conditions at a significantly slower speed than was the case with the NM control condition and MTM treatment condition.

There are only two participants, represented by the blue and red lines, whose lap-times increased from the MTM treatment condition to the HTM treatment condition. However, the results in general seem to suggest that the participants started off at a slower pace, which quickened towards the HTM treatment condition.

The general conclusion from the results pertaining to LT indicates that the tempo of music exerts a direct influence on speed, thereby influencing driving ability as hypothesised.

Table 4.8: *Means comparisons between treatment conditions for lap-times*

q*	Alpha
2.73031	0.05

Abs(Dif)-LSD	**Control**	**Low**	**Medium**	**High**
Control	-10.9728	-3.41293	2.251988	2.695842
Low Tempo	-3.41293	-10.9728	-5.30793	-4.86408
Medium Tempo	2.251988	-5.30793	-10.9728	-10.529
High Tempo	2.695842	-4.86408	-10.529	-10.9728

Positive values show pairs of means that are significantly different.

The results obtained in Table 4.8 indicate an alpha level of p<.05, meaning that there is less than 5% risk that the results obtained in the study are due to chance. Thus, tentative conclusions can be reached by assuming that the results obtained were not based on chance but indicative of a possible relationship existing between the tempo of music and driving behaviour. Driving behaviour, as stated throughout this document, is represented by the speed with which participants successfully completed laps. This was concluded with respect to the sample which included eight participants (N=8).

Table 4.8 further indicates a significant difference between the NM control condition and the MTM (2.251988) and HTM treatment conditions (2.695842).

4.3 CONCLUSION

Statistical results indicate that the tempo of music does not appear to be causally implicated in a loss of concentration while driving. Rather, individual characteristics appear to play a role, and account for the effect of musical tempo on concentration. Furthermore, these results seem to imply that many other factors such as personality and personal preference as regards music should also be considered and that these could affect the relationship between music tempo and concentration. Thus, H1 and H2 were disproved because the results indicate that no relationship exists between concentration and driving ability.

H3, which was originally supposed to be a result of a decrease in concentration, was found to be an independent occurrence. Thus, an increase in speed (representative of driving behaviour) appears to be influenced by the tempo of music. The results indicate that a systematic increase in tempo leads to an increase in speed.

CHAPTER 5:

CONCLUSIONS, DISCUSSION AND RECOMMENDATIONS

5.1 A GENERAL DISCUSSION

An exploratory investigation was conducted in order to determine whether the tempo of music indeed influences driving behaviour. Even though both constructs have been investigated thoroughly, insufficient information has been found with regard to the relationship between concentration and the tempo of music. The study can therefore be regarded as a pilot study, and an initial entry point for investigating the relationship between these two constructs. However, despite the small sample size, informative results were still obtained. These results can be applied to subsequent research involving larger sample sizes and more sophisticated research techniques. These techniques could include the use of driving simulators or the analysis of driving behaviour in real traffic situations using eye-tracking technology.

Does the tempo of music cause a decrease in concentration while driving and in turn influences driving ability? In order to determine whether this is true, it was hypothesised (H1) that the tempo of music influences concentration while driving. It was also hypothesised (H2) that high tempo music causes a larger decrease in the amount of concentration when driving as opposed to low and medium tempo music. Finally, it was hypothesised (H3) that the tempo of music influences driving behaviour.

Thus, the aim of the study was to investigate the amount of DE made in the presence of the NM control condition and the LTM, MTM and HTM treatment conditions. By means of observing and recording the amount of DE, it was possible to determine whether the tempo of music has an influence on concentration while driving. Results indicate no significant influence on concentration (as stated in H1 and H2), thus disproving the hypothesis.

Results do however, indicate that behaviour while driving is significantly influenced by the presence of music as proposed in H3. This was concluded from the results which indicate that speed increases systematically as the tempo of music increases. More specifically, it was investigated whether high tempo music has a more significant influence on concentration as opposed to no music and low tempo and medium tempo music. Furthermore, another point of investigation was to observe the behaviour of participants while they listened to music and drove, and the responses that were elicited therefrom.

The following section will discuss the implications relevant to the study as well as identify the study's shortcomings. These shortcomings could be addressed in future studies.

5.2 STATISTICAL RESULTS OBTAINED FROM THE DATA

The following section provides an overview of the results obtained and discussed in Chapter 4, and provides literature relevant to those results.

5.2.1 Testing for normality

Even though a small sample size was utilised (n=8), statistical analysis of the data suggests that the data collected from the participants in the experiments display a relatively normal distribution. This suggests the presence of a possible pattern in the relationship between the tempo of music and concentration, as well as the tempo of music and driving behaviour.

In order to determine whether there is an actual relationship between the tempo of music, concentration and driving behaviour, a larger sample size has to be utilised before the results can be accepted as valid with confidence. Since the study was conducted by means of simulation, the limitations pertaining to this should be taken into consideration. However, the simulation exercise was employed based on the assumption that it represented a relatively real driving experience which would elicit similarly real behaviour. The simulations also ensured that the study could be conducted in a completely safe manner.

Based on the indication of a relatively normal distribution of the results, parametric methods were applied for the remainder of the statistical analysis conducted on the data. Normality curves obtained for both LT and DE are illustrated in Figure 4.1 and Figure 4.2.

5.2.2 Statistical analysis conducted to determine significant variables contributing to the results obtained

An ANOVA indicated that significant results were obtained for the model; this is indicative of the study as a whole. The tempo of music was found to have influenced driving ability in terms of an increase in speed as the tempo of the music increased. However, existing studies and discussions, as mentioned in Chapter Two, which were presented by Dibben and Williamson (2007), Boer et al. (2006), Galotti (2004), Beh & Hirst (1999), Kiger (1989), Konečni and Sargent-Pollock (1976), Hargreaves and North (2008), Beeld (2010), Feaganes et al. (2005) and Behm et al. (2007) provided support for the notion that music does have an influence on concentration. This however was not found to be the case with this study.

DE, which was said to indicate a lack of concentration while in the presence of music, did not correlate with the tempo of music presented in each of the treatment conditions as originally proposed. Further analysis was conducted in order to accurately determine which factors accounted for the observed relationships between the tempo of music, and concentration and driver behaviour.

5.2.3 Statistical results obtained from driving errors

When investigating DE, the results indicate that the participants themselves have a significantly greater influence on concentration in comparison to the tempo of music than originally hypothesised (H1). Personality factors could therefore be attributed to be the main determining factor for results pertaining to DE, that is the individual differences presented by the participants during the study. This was concluded from the results in which DE provides no indication of significance or a contribution from the NM control condition, or the LTM, MTM and HTM treatment conditions. Thus, the results do not provide support for H1 which states that the tempo of music is a cause for the decrease in concentration while driving.

Individual differences could be ascribed to personality factors such as personal musical preferences that influence performance while driving (Berlyne, 1971; Hargreaves and North, 2008), or emotional reactions caused by associations attached to specific songs (Boyle and Radocy, 2003; Bruner, 1990; Hargreaves and North, 2008) and possibly other musical elements such as intensity, frequency, volume, duration, preference, familiarity and type (Beh & Hirst, 1999; Behm & Dalton, 2007; Hargreaves & North, 1999). Other elements inherent in music, such as vocals, instruments and language-use could also be alternative causes for DE. Each of the above variables could possibly have affected the participants, and thus are also likely to have an effect on individuals in real driving situations.

Standard deviation scores indicated for DE in Table 4.7 are significantly higher than those obtained for LT, which means that unlike the standard deviations providing support for the hypothesis with regards to LT, the standard deviations obtained for errors do not furnish statistical support for the notion that concentration is influenced by the tempo of music.

Possible causes for the occurrence of large variances between the means for the NM control condition and the LTM, MTM and HTM treatment conditions could be the order in which each treatment condition was presented; this order was randomised in an attempt to counteract practice effect. The amount of DE made by the participants may have decreased as exposure to the study continued. Participants may therefore have become accustomed to driving in this manner and thus managed to successfully improve their driving performance, thereby accounting for less DE in certain treatment conditions as opposed to others: for example, the difference in means obtained between the NM control condition and the HTM treatment condition.

In addition, other possible influences on concentration in relation to music, such as intensity, volume, duration, frequency, familiarity and type, are not accounted for in this study. These elements were not included for investigation as the focus of the study was placed on tempo and its influence on concentration. However, even though these additional elements were not included in the investigation, they are present in all music and could therefore be regarded as possible influences on concentration, despite not being investigated.

Additional ways in which participants could have been influenced include increased arousal (Hargreaves and North, 2008; Boyle & Radocy, 2003; Berlyne, 1971) which may have caused an over-excitatory reaction or possibly even fatigue. If the music used in each treatment condition did affect participants, it may have contributed negatively; the behaviour elicited and recorded may not have been a true reflection of behaviour that the participants would elicit in real-life driving experiences. As already pointed out, this study merely simulated the effect of driving, and can therefore not be regarded as a real-life driving experience.

In general, based on observations and statements made by the participants during the study, the majority of participants indicated a liking for some of the music in the study. These preferences usually pertained to one or two of the treatment conditions. This preference was supported by the behaviour unconsciously displayed by participants; bodily mannerisms such as singing, bumping their heads or dancing along to certain music were evident.

Figure 4.3 indicated that DE was more likely to occur in the MTM and HTM treatment conditions as opposed to the NM control condition and LTM treatment condition. This provides supporting evidence for H2 by indicating that higher tempo music in general (uncategorised) does have an influence on concentration while driving. However, when focusing on the music classified between 60 BPM and 120 BPM (MTM), most errors were recorded under this treatment condition, and not the HTM treatment condition as originally hypothesised. Thus, the results obtained do not provide supporting evidence pertaining to the influence of musical tempo on concentration as stated in H2. One specific track in the HTM treatment condition contained a profanity; this track was recorded by Linkin Park under the title *Bleed it out,* and since more errors were recorded in the MTM treatment condition, swearing is not considered to influence the amount of errors as this track was presented in the HTM treatment condition which indicated less DE.

The NM control condition compared to the LTM treatment condition indicated that more errors occurred within the former, as opposed to the latter. A possible reason for this could be ascribed to a novelty effect. Since the NM control condition was presented as the first condition to each participant, such an effect could have been the cause for the poor results. Thus, the said effect is a possible cause of a decrease in concentration.

No scientific evidence can be presented in terms of neural functioning in the study as no neuro-scientific research was employed for investigation in the study. Conclusions are drawn based on the literature discussed in Chapter Two; in addition, it is suggested by Culbertson et al. (2008) that there are overlaps between the thalamus and the supramarginal and angular gyri of the inferior parietal lobes which join Wernicke's area.

However, this does not provide sufficient evidence on which accurate conclusions can be drawn, as these regions are postulated to act as relay stations only. Furthermore, Grahn (2009) states that evidence indicating an overlap between neural networks does not necessarily indicate that the two regions function as one. An overlap in relation to this study refers to the processing and interpretation of both auditory and visual information by the same brain regions.

The results obtained in the study could possibly provide supporting evidence for the notion discussed in Chapter Two by Galotti (2004), Geringer and Nelson (1979) as well as Etaugh and Michals (1975) that that there is no competition for attentional resources as the two brain regions processing visual and auditory information constitute two distinct neural systems (Grahn, 2009). This conclusion is based on the statistical results which indicate no significant evidence that concentration is influenced by the tempo of music. Galotti (2004) states that people can learn to conduct numerous tasks simultaneously. This, in layperson's terms, can be referred to as multi-tasking. People therefore learn to drive and attend simultaneously to other tasks such as making conversation, focusing on the external environment and making adjustments in the car.

5.2.3.1 Late-selection theory

Late-selection theory implies that incoming visual and auditory stimuli are processed simultaneously. Information is extracted from both stimuli but the stimulus perceived to be more important takes precedence and is processed in more detail while the message perceived as secondary is discarded. It is stated that the importance of a message is determined by the context and personal significance of the content (Galotti, 2004).

Thus, because the task of driving is deemed important, the driver's attention should automatically focus on the road and this task should take precedence over any incoming auditory stimuli; the only other stimuli to be processed would be those related to the road and the driver's surroundings. However, if auditory information such as in-vehicle music somehow becomes the preferred stimulus, it is assumed that the visual stimuli would be discarded, thus increasing the chance of driver errors. This however, was found to be false regardless of the tempo of music in either the LTM, MTM or HTM treatment conditions.

5.2.3.2 Multimode theory

For the purpose of the study and its results, multimode theory seems most applicable. It is suggested that attention is flexible, thus making it possible to switch from one stimulus to another as one desires. Hence one can switch between visual and auditory information as deemed necessary by the individual. However, if one or both of the stimuli are perceived as equally complex, an increased amount of attentional resources are required to process the incoming information.

The concept of the ability of an individual to alter his/her attention is applicable at this point; it can be assumed that drivers have the ability to decide on which incoming stimuli they should focus. For example, although a driver's main focus is on the road and its surroundings, he/she can shift their attention to the radio to make adjustments.

Another concept which is recognised as an independent factor and can be incorporated with the concept of multimode theory is the concept of divided attention. This refers to the ability to focus on more than one stimulus at any given time. Individuals are thus assumed to have the ability to divide their attention between visual and auditory information, although, according to Culbertson et al. (2008), only to a certain degree. This can be connected to the availability of attentional resources as the determining factor for the extent to which a person is able to divide their attention. Applied practically, a driver is able to perform numerous tasks simultaneously.

5.2.3.3 Attentional resources and the focusing of attention

Galotti (2004, p. 100) states that "the individual deposits mental capacity to one or more of several different tasks". Many factors influence this allocation of mental capacity, which itself depends on the capacity and type of mental resources available. The availability of mental resources, in turn, is affected by the overall level of arousal, or state of alertness. This implies that an individual in a driving context determines what is to be the focus of attention, and can therefore focus on more than one stimulus.

Focusing on numerous factors at once is automatically a prerequisite as a driver has to focus not only on the road ahead, but also on surrounding cars, on traffic, on managing the controls inside the car, on road signs and on external sounds all at once. The vigilance exerted by a driver on the road determines the amount of mental resources which are available to process all of the incoming information. Therefore, if an individual is tired, the level of alertness is low and thus the amount of mental resources available will also be low.

This provides supporting evidence for the results obtained for LT. If HTM is played while driving, the arousal caused by the music increases the alertness during the task of driving. This in turn increases the amount of mental resources that are available, which allows for the processing of more incoming stimuli. Thus, not only is concentration not negatively influenced by an increase of mental resources, but drivers are also unconsciously influenced by the arousal that leads to excitation.

5.2.4 Statistical results obtained from lap-times

Participants generally took longer to complete the NM control condition as opposed to the time it took to complete the LTM, MTM and HTM treatment conditions in which time decreased significantly. Supporting evidence for H3 was obtained, which indicates that speed systematically increased as the tempo of music did. This means that the speed at which LT was completed increased from the NM control condition until the HTM treatment condition, in which the fastest LTs were recorded.

The NM control condition was presented to each participant as the first treatment condition, followed by the three remaining treatment conditions (LTM, MTM and HTM). These treatment conditions were randomised for each participant. The NM control condition represented a baseline condition for each participant which could then be compared to the LTM, MTM and HTM treatment conditions.

In doing so, it is assumed that the no-music treatment condition did not influence the results obtained in the study. It is possible that the overall lap times of the participants were slower for the NM control condition as it was unfamiliar, being the first treatment condition they were exposed to. Thus speed may have increased as the study progressed due to the increasing familiarity with the track and the task. However, the remaining three treatment conditions (LTM, MTM and HTM) were randomised for each participant, meaning that participants were not exposed to these treatment conditions in the same order. In doing so, the possibility of a practice effect was assumed to be counteracted and it was therefore concluded that the results obtained for the lap-times are accurate and reliable.

Results also indicated that the mean data obtained differs significantly between the NM control condition and the HTM treatment condition. Standard deviations obtained between the NM control condition and the LTM, MTM and HTM treatment conditions indicate little variation, all of which is indicative of an increased probability that the results obtained were not due to chance. It is thus possible to suggest that music's tempo did have an influence on driving behaviour.

Speed is postulated to be an effect of excitatory arousal as proposed by Hargreaves and North (2008), and excitatory arousal in this study is proposed to be a result of musical tempo. An example is presented by Hargreaves and North (2008) which differentiated between the type of music played at a pep rally as opposed to the type of music played before one goes to bed. A pep rally obviously makes use of HTM in order to elicit an increase in energy and thus excitatory arousal, while the music one plays before going to bed serves a calming purpose. If high tempo music is employed at pep rallies to create excitement, then it can only be concluded that this would be applicable to all contexts. Obviously the type of behaviour that is elicited in each specific context differs. The tempo of music was predicted to have the same effect while driving: an increase in speed as the tempo of music increases. Speed was regarded to be indicative of driving behaviour, and this is evident in the results. It is postulated that in a driving context, the effect of music will be indicated by speed and observable behaviour such as bodily mannerisms. As mentioned, participants danced, bumped their heads and sang along to the pre-selected music employed in the LTM, MTM and HTM treatment conditions.

Furthermore, it is concluded that participants "feel" the beat contained in the music, which could cause the activation of excitatory emotions. It appears as if participants were unaware of the fact that their behaviour was influenced by the tempo of music. This can be ascribed to a natural response of the human body and Berlyne (1971) attributes it to psychobiological factors. A similar concept is also discussed by

Hargreaves and North (2008) who state that music has a psychological effect which is illustrated by arousal. This means that HTM could have an effect on the amount of arousal experienced. LT in the study was recorded as significantly faster in the HTM treatment condition, which implies that high tempo music could be causally implicated in excitement and stimulation experienced as a result of higher arousal. This in turn could be the cause of the increase in speed. Thus, some support for this interpretation is evident because HTM corresponds to a significant increase in LT.

Berlyne (1971) finds that the psychophysical effect of the increase in music's tempo and volume is heightened arousal. Other factors considered by Berlyne (1971) include the ecological meaning which refers to the complexity of music. This means that the more an individual is familiar with a certain type of music, the less arousal it is assumed to elicit. This implies that if an individual prefers and is accustomed to a certain type of music, such as heavy-metal, it will have less of an effect on that individual than on another individual who usually listens to classical music. The excitatory effect of high arousal music is attributed to its tempo. Thus, higher tempo music is a possible cause for excitatory behaviour which in turn could cause an increase in speed, as indicated by the results obtained from the study.

An observation made during the course of the study was that one participant said that he/she usually listens to music with an even higher tempo than that employed in the study. The performance of that participant remained constant throughout the study in all four treatment conditions. Because of this participant's familiarity with more stimulating music, it is possible that the pre-selected music in the study did not influence that participant. In such an instance, no arousal would have occurred. With regard to preference, the above information is definite evidence that preference is certainly a determining factor with regard to performance. This particular participant also reported that the LTM treatment conditions were irritating.

Each participant was instructed to remain within a speed limit of 80 kilometres an hour as the track on which they completed the study had numerous difficult and sharp turns. Driving in this manner for the first time was anticipated to be a difficult task for the participants. Each participant was instructed to complete each lap as quickly as possible but told that remaining on the blue line (their accuracy) was more important than speed. Participants acknowledged their understanding, but in the study it was found that all of the participants began to increase their speed as they became more comfortable with the task. It was also observed that the higher the tempo of the music accompanying each participant, the faster they were inclined to drive. After some time, all of the participants completely disregarded the speed limit. That the participants eventually disregarded the speed limit could be seen as having a negative effect on the standardisation of the study, but it also provided vital information. Given that this behaviour occurred repeatedly throughout the experiment, it can be concluded that higher tempo music could cause an unconscious increase in driving speed.

5.2.4.1 Novelty effect

In Chapter 2, theories of attention assumed to be relevant to the study were discussed. Galotti (2004) stated that the amount of concentration required in a specific situation is determined by the complexity of the task at hand. Novice drivers in real-life driving situations could find the task of driving extremely overwhelming, especially when they are not only required to focus on the road, but also attend to traffic, in-vehicle functions, weather conditions and even the car music system. Confirmatory evidence stated by Lee (2007) indicates that novice drivers have a greater likelihood of being influenced by external factors than would be the case for more experienced drivers.

However, it is postulated that the mentally taxing experience of performing multiple tasks simultaneously while driving may also be applicable to experienced drivers. This is because cognitive resources are assumed to be limited (Galotti, 2004). The performance of multiple tasks simultaneously, and the amount of mental resources available, was the underlying relationship assumed to influence concentration.

The novelty effect, however, is not considered to have an influence on the results in the study. Although all of the participants were entirely inexperienced with regard to console gaming on a Playstation 3, they were presented with the opportunity at the onset of the study to familiarise themselves with driving in this manner. This effect is thus excluded as a factor contributing to the results obtained. Again, LT results indicate that the findings are free from the influence of such an effect because participants experienced the NM control condition and the LTM, MTM and HTM treatment conditions in different orders. It is therefore concluded that no behavioural and expectancy pattern developed amongst the participants because of the randomisation of the treatment conditions.

5.3 THE IMPLICATION OF THE OBTAINED STATISTICAL ANALYSIS RESULTS FOR THE STATED HYPOTHESIS

Statistical analysis of the results pertaining to H1 suggests that music's tempo does not have an influence on concentration while driving. Individual characteristics however, were found to be the reason for a decrease in concentration observed while driving. The full extent of individual differences, including personality characteristics, arousal and excitatory behaviours and fatigue, influencing concentration while driving is unknown.

Secondly, as H1 was found to be false, the conclusion that HTM will not lead to a decrease in concentration must be drawn. This is because the tempo of music was proven to be irrelevant with regards to music and its influence on concentration. Furthermore, DE occurred more frequently in the MTM treatment condition as opposed to the HTM treatment condition. This provides additional evidence that there is no relationship between HTM and concentration as stipulated in H2.

With regard to H1 and H2, no confirmatory evidence has been found suggesting that concentration was influenced by the tempo of music.

Finally, with regard to H3 (investigating whether the tempo of music influences driving behaviour), the hypothesis was found to be true. Significant results were obtained indicating that driving behaviour is directly influenced by this factor. It was found that speed is associated with the tempo of music, meaning that speed systematically increases as the tempo of music increases.

5.4 ADDITIONAL INFORMATION OBTAINED BY MEANS OF ALTERNATIVE APPROACHES

5.4.1 Information obtained from the questionnaire

Appendix C provides a copy of the questionnaire used before volunteers took part in the study. The questionnaire served the purpose of providing additional information about each participant's conscious choices and behaviours while in a normal driving situation. This includes the participant's preferred music and whether they listen to music or radio while driving. Participants were requested to indicate the amount of time they have held their driver's licence, as a two year minimum was required for participation. Biographical information was also requested for statistical purposes which included the participant's age, gender and race.

One specific question asked "Do you sometimes experience that listening to music influences your concentration while driving?" and was accompanied by a scale ranging from 1 to 5 (1=never; 5=always). This question provided vital information as it indicates whether the participants perceive music to influence their concentration while driving or not. From the eight participants (N=8) who took part, three participants (N=3) indicated a 2 on the scale, another three participants (N=3) indicated a 3 on the scale and two participants (N=2) indicated a 4 on the scale. Thus, five participants (N=5) indicated a 3 or higher on the 5-point scale. From this, the conclusion was drawn that the majority of the participants perceive music to influence their concentration while driving.

Statistical results however, indicate that concentration is not influenced by the tempo of music. Based on this, the conclusion can be drawn that participants are able to perform multiple tasks (driving and listening to music) simultaneously as indicated by Galotti (2004).

5.4.2 Behaviour observed during the study

Participants reported that they enjoyed the pre-selected music after completing the study, and this was evident by the behaviour observed during their participation. The majority of the participants were singing- and moving along to the music utilised in the study.

One participant reported preferring the NM control condition and LTM treatment condition more than the MTM and HTM treatment conditions. Another participant enquired about the music employed in the LTM treatment condition because of a particular enjoyment of that music.

It was observed that different treatment conditions had different effects on some participants: one participant appeared to perform better when accompanied by the MTM treatment condition. Another participant, who completed the LTM treatment condition last, appeared to be calmer and to have driven slower than in the HTM treatment condition completed just before that. The same participant reported that when preferred music was played, it had a greater influence on his/her concentration and performance.

Another participant reported a preference for driving faster and thus exceeded the speed limit from the onset of the study. It also appeared as though speed, during the LTM treatment condition, increased when that participant intently focused on the music. That participant's speed also increased in both the MTM and HTM treatment conditions. This participant also seemed to get frustrated when he/she made errors. It is not clear whether this was due to the frustration of the participant at not successfully fulfilling the requirements, or whether it was due to the steering wheel as this participant had complained about it from the very beginning of the practise session.

The steering wheel was generally criticized for being limited in its range of motion and its overly sensitive steering. However, this is common to all console gaming steering wheels and was not an isolated problem.

Another participant's bodily movements, in the form of dancing along to the music, were observed and their speed increased as the tempo of music increased. It was observed with another participant that their speed was significantly less when a particular song was played in comparison to the other music in that condition. This track was recorded by Lenny Kravitz under the title, *Calling all angels*. This specific participant appeared to have performed optimally in the MTM treatment condition and seemed to have the fastest LT in the HTM treatment condition.

One specific participant's hands were shaking terribly during the practice session. Due to these types of involuntary reactions and behaviours, it was deemed vital to include a practice session in order to ensure the comfort of the participants such that their actual behaviour could be observed and recorded.

All of the indicators pertaining to an increase in speed in the HTM treatment condition are supportive of the statistical findings discussed earlier in this chapter. It can therefore conclusively be said that the tempo of music does have an influence on speed, and consequently on driving behaviour.

5.5 RELIABILITY AND VALIDITY OF THE STUDY

5.5.1 Reliability

It was initially proposed to include a co-observer for the purpose of achieving inter-rater reliability. Using a co-observer would have ensured that the observations made were thorough, detailed and accurate. However, due to unforeseen circumstances, the individual originally employed for this purpose withdrew and could not render assistance as originally agreed. Possible human errors therefore cannot be excluded, because the observations were recorded by the researcher alone.

In order to compensate for the loss of a co-observer, a save game function was utilised. This function allocates a number to a single run under which each treatment condition was saved. The corresponding number was then copied to the participant's scoring sheet for that specific treatment condition. Hence, by implementing this function, the data associated with the different treatment conditions for each participant could be saved and entered separately. This allows for the reviewing of any specific participant's treatment condition with the option of rescoring lap-times and errors, for checking purposes.

Although this option provided the best possible solution to the problem, the main weakness of this save game function is that the music that accompanied a participant at a specific stage in a treatment condition is not necessarily restarted at the same point that it was at previously. Even though the music accompanying each treatment condition started at the same point for each participant, human error could still have occurred. Another limitation is that behaviour elicited by the participants could not be recorded for later viewing as was the case with DE and LT. This may be due to the fact that the researcher was required to record all information without help and could thus not record any detailed behaviour as well.

It was found that human error comes into play particularly when utilising the save game function and having to rescore errors. Each time an error was rescored, deviations from the original score recorded on the day of the study were obtained. It is therefore suggested that the best solution to this problem is to obtain an average error score after recording it successively in three trials. This will provide a more accurate and reliable score for DE.

As discussed in Chapter Three, the service of a social sciences statistician was employed. The statistical results were interpreted by the researcher and communicated to the statistician who ensured the correct interpretation, and that correct and appropriate conclusions were made based on the statistical results. This provided the accurate and reliable statistical results presented in Chapter Four as the data was analysed by a professional in the field of statistics.

5.5.2 Validity

Face validity was utilised as LT, DE and behaviour elicited were personally recorded, scored and verified by the researcher.

5.6 SUGGESTIONS FOR FUTURE RESEARCH

In the study, statistical analysis was conducted in order to determine the factors that resulted in a decrease in concentration. This was conducted on the variables that were included for investigation in the study, namely tempo of music and concentration (which were proposed to be indicative of DE, and driving behaviour). Future studies should consider employing a larger sample size as well as investigating other elements of music such as volume, duration, intensity and genre.

With the utilisation of a larger sample size, researchers would be able to generalise the results to the general population, making the concept of music and its influence on driving applicable to everyone. Furthermore, with regard to generalising the obtained results, it is suggested that the study be conducted using real-world situations as opposed to the simulation of this study. Simulation poses threats to the reliability and validity of not only the manner in which the study was conducted, but also the results obtained. Thus the study is best seen as a pilot study which simply determines whether there is a relationship between the tempo of music, and concentration and driving behaviour.

In the study under investigation, a pre-test questionnaire (Appendix C) was included which contained questions regarding the participants' general experience while driving under normal conditions. More specifically, this sought to determine whether participants listen to music while driving and what type of music they prefer to listen to. Another reason for the pre-test questionnaire was to determine whether participants perceive music to influence their concentration in a real-life driving context as discussed above. However, it would be beneficial in future research studies to obtain the participants' feedback (in a post-test questionnaire) after their participation in such a study in order to determine whether they felt an influence on their concentration and driving ability by tempo. The post-test questionnaire may also include other questions pertaining to the degree of stress, fatigue and boredom experienced during the course of the study.

For future adaptation of the study, it is further recommended to continue randomising the different music treatment conditions as done in this study; however, the order of randomisation should be standardised for all of the participants with the NM treatment condition fixed as the first treatment condition.

In order to achieve results for test-retest reliability, it should be considered that the study be re-conducted on the same sample group in order to compare the results between the first and second data sets (Forzano & Gravetter, 2006). Thus, every participant who volunteered for the original study would fulfil the same tasks, but with a different sequence of musical tempos. This would determine whether the results obtained in the first study were an accurate reflection of the participant's performance, and eliminate the possibility of the results being influenced by chance. By doing so, the results would indicate whether the performance of each participant is stable over time, and thereby indicate more accurately what effect different musical tempos have on behaviour.

In the case that this study is replicated or altered by another researcher, it would be beneficial for those researchers to use an Electroencephalogram (EEG) and Electrooculography (eye-movement tracking). These instruments measure and record brain wave activity (EEG) and eye movement (Electrooculography). More recently developed techniques should also be considered, such as Magnetoencephalography (MEG), Functional Magnetic Resonance Imaging (fMRI), and Position Emission Tomography (PET). These three brain-imaging techniques could provide useful indications of brain activity while driving and listening to music are performed simultaneously. This would provide insight into the neurological functions of a participant, which could not be investigated in this study. This could also furnish an indication of the emotional responses experienced by the participants and could help minimise the chances of human error affecting the study (Hodges, 1996). The truth of the matter is, however, that nothing can be measured without error. Thus, by employing the abovementioned technologies, human error (observation and face validity) is limited as the recording is conducted by standardised equipment. Human error is, of course, still applicable with regard to the interpretation of these techniques.

5.6.1 Suggestions for the prevention of accidents in the African context

Lagarde (2007) discussed road-accident prevention measures, however, in order to apply any preventative strategies in Africa, its perception towards road safety must first be understood first. Due to the lack of research in this regard, inadequate knowledge is currently available. This contributes to the misunderstanding of principles of road safety.

Information which is available relates to “the superstition of cab drivers, the perception of accident causes, youth risk behaviour and the psychosocial impact of road traffic injuries on drivers and relatives” (Lagarde, 2007, p. 969). Furthermore, one suggestion for ensuring a decrease in the number of deaths on the public roads, is by enforcing speed control. Road infrastructure is one factor which is normally deemed important by the government (Lagarde, 2007).

Vigilance and awareness are important factors which could possibly combat the effect of music while driving. This means that if an individual remains aware of the speed at which they are driving and focuses on the road, while remaining aware of other motorists around him/her, it is postulated that in-vehicle music should not act as a distraction, provided that he/she is cautious with regard to the volume and type of music they play. Being patient towards other drivers on the road is another way to combat the increasing occurrence of motor-vehicle accidents.

5.7 CONCLUSION

Statistical analysis conducted on the data in the study indicates tentative results that need further exploration in future studies. This study could serve as an entry-point for future researchers with regard to investigating musical tempo and its influence on driving. The results suggest that concentration is not influenced by the tempo of music even though it does have a direct influence on driving behaviour.

It was postulated that the study could create awareness of the influence that music has on concentration and driving ability. However, findings in the study do not provide support for this notion even though the results of previous studies have suggested otherwise. Speed however, postulated to be representative of driving behaviour, is found to be directly influenced by the tempo of music.

Even though the results are not representative of the general population at this stage, future studies could utilise a larger sample size from which conclusions can be drawn which can be generalised to the general population. The reason why this study may eventually be applicable to the general population is that obtaining a driver's license and driving a motor vehicle are applicable to the majority of the population.

In conclusion, although this study can only be regarded as a pilot study, it does provide valuable insight and information, and suggest new methods for future application. The influence of the tempo of music on concentration has not yet reached its full potential in the realm of research, and thus there is significant room for improvement. If research is conducted appropriately, vital information can be generalised to the whole population. This is because music is said to be a form of international language; a generally accepted form of communication understood by all. The results obtained from such a study have the potential to influence hundreds of thousands of individuals globally. This indicates the ability of researchers to create an effect on a large scale. However, it must be remembered that great power must be supervised with even greater responsibility.

REFERENCE LIST

Agnew, S., Darrow, A., Johnson, C. M. & Rink, E. (2004). The effect of preferred music as a distraction on music majors' and nonmusic majors' selective attention. In *Proceedings of the 8th International Conference on Music Perception & Cognition, 3-7 August 2004* (pp. 763-766). Adelaide, Australia: Causal Productions.

Akai, S., Nakajima, Y., Nittono, H. & Tsuda, A. (2000). Tempo of background sound and performance speed. *Perceptual & Motor Skills, 90,* 1122.

Aston-Jones, G., Cohen, J. D. & Gilzenrat, M. S. (2004). A system-level perspective on attention and cognitive control: Guided activation, adaptive gating, conflict monitoring, and exploitation versus exploration. In M. I. Posner (Ed.), *Cognitive neuroscience of attention* (pp. 74-76). New York, USA: Guilford Press.

Atkinson, J. & Hood, B. (1997). Development of Visual Attention. In Burack, J. A. & Enns, J. T. (Ed.). *Attention, Development, and Psyhopathology,* (pp. 31-54). New York, USA: The Guilford Press.

Baker, T. W., Bloomfield, J. R., Brown, T. L., Grant, A. R., Layton, T. A., McKenzie, D. R., Watson, G. S., Weiler, J. M. & Woodworth, G. G. (2000). Effects of fexofenadine, diphenhydramine, and alcohol on driving performance: A randomised, placebo-controlled trial in the Iowa driving simulator. *Ann Intern Med, 132,* 354-363.

Bauer, T. (2009). *System response times in a simulated driving task: Effects on performance, visual attention, subjective state and time estimation.* Master's thesis. Pretoria, SA: University of South Africa.

Beh, H. C. & Hirst, R. (1999). Performance on driving-related tasks during music. *Ergonomics, 42*(8), 1087-1098.

Behm, D. G. & Dalton, B. H. (2007). Effects of noise and music on human and task performance: A systematic review [Abstract]. *Occupational Ergonomics, 7*(3), 143-152.

Behm, D. G., Dalton, B. H. & Kibele, A. (2007). Effects of sound types and volumes on simulated driving, vigilance tasks and heart rate [Abstract]. *Occupational Ergonomics, 7*(3), 153-168.

Bellinger, D. B., Berg, W. P., Budde, B. M., Machida M. & Richardson, G. B. (2009). The effect of cellular telephone conversation and music listening on response time in braking. *Transportation Research Part F, 12,* 441-451.

Berg, W. P., Consiglio, W., Driscoll, P. & Witte, M. (2003). Effect of cellular telephone conversations and other potential interference on reaction time in a braking response. *Accident Analysis and Prevention, 35,* 495-500.

Berlyne, D. E. (1971). *Century Psychology Series: Aesthetics and Psychobiology.* New York, USA: Appleton-Century-Crofts.

Boer, E., Levy, J. & Pashler, H. (2006). Central interference in driving: Is there any stopping the psychological refractory period?. *Association for Psychological Science, 17*(3), 228-235.

Boyle, J. D. & Radocy, R. E. (2003). *Psychological Foundations of Musical Behaviour* (4^{th} Ed.). Illinois, USA: Charles C Thomas.

Broadbent, D. E. (1958). *Perception and Communication*. New York, USA: Pergamon Press.

Brodsky, W. (2002). The effects of music tempo in simulated driving performance and vehicular control. *Transportation Research Part F, 4,* 219-241.

Brookhouser, P. E. (2000). Nongenetic sensorineural hearing loss in children. In R. F. Canalis & P. R. Lambert (Eds.), *The ear: Comprehensive otology* (pp. 489-510). Philadelphia, USA: Lippincott, Williams & Wilkins.

Bruner, G. C. (1990). Music, mood, and marketing. *Journal of Marketing, 54*(4), 94-104.

Bruno, J. P., Givens, B. & Sarter, M. (2001). The cognitive neuroscience of sustained attention: Where top-down meets bottom-up. *Brain Research Reviews, 35,* 146-160.

Car-accidents.com. (2008). South Africa Accidents: Pictures, stories & info. Retrieved June 9, 2009, from http://www.car-accidents.com/country-car-accidents/south-africa-car-accidents-crash.html.

Castell, K. C. & Hargreaves, D. J. (1987). Development of liking for familiar and unfamiliar melodies. *Council for Research in Music Education Bulletin, 91,* 665-669.

Chen, J. L., Penhune, V. B. & Zatorre, R. J. (2007). When the brain plays music: Auditory-motor interactions in music perception and production. *Nature Reviews: Neuroscience, 8,* 547-558.

Cherry, K. (2011). *Wernicke's area*. Retrieved January 26, 2011 from http://psychology.about.com/od/windex/g/def_wernickesar.htm.

Cohen, R. A. (1993). *The Neuropsychology of Attention.* New York, USA: Plenum Press.

Coull, J. T., Frith, C. D., Maquet, C. D., Mesulam, M. M., Nobre, A. C. & Vandenberghe, R. (2004). Orienting attention to locations in perceptual versus mental representations. *Journal of Cognitive Neuroscience, 16,* 363-373.

Cropper, M. & Kopits, E. (2005). Traffic fatalities and economic growth. *Accident Analysis Prevention, 37,* 169-178.

Culbertson, W. C., Spiers, M. V. & Zillmer, E. A. (2008). *Principles of Neuropsychology* (2nd ed.). Belmont, USA: Thomson/Wadsworth.

Day, K. (2004). *Music and the mind: Turning the cognition key.* Retrieved November 26, 2010, from http://www.northwestern.edu/observer/issues/2004-10-21/music.html.

Deutsch, D. & Deutsch, J. A. (1963). Attention: Some theoretical considerations. *Psychological Review, 70,* 80-90.

Dibben, N. & Williamson, V. J. (2007). An exploratory survey of in-vehicle music listening. *Psychology of Music, 35*(4), 571-589.

DiGirolama, G. J. & Posner, M. I. (1998). Executive control: Conflict, target detection, and cognitive control. In R. Parasuraman (Ed.), *The attentive brain* (pp. 401-424). Cambridge, MA: MIT Press.

Dj BPM Studio. (2008). *Beat matching on demand.* Retrieved July 27, 2010, from http://djbpmstudio.com/index.html.

Du Plooy, D. (2010, 22 September). Doef-doef kan lei tot n karongeluk. *Beeld.*

Durant, J. D. & Ferraro, J. A. (2000). Physiologic acoustics – the auditory periphery. In R. F. Canalis & P. R. Lambert (Eds.), *The ear: Comprehensive otology* (pp. 89-112). Philidelphia, USA: Lippincott, Williams & Wilkens.

Etaugh, C. & Michals, D. (1975). Effects on reading comprehension of preferred music and frequency of studying to music. *Perceptual and Motor Skills, 41*, 553-554.

Facebook. (2010). *Lowering the music when looking for a street address so I can see better.* Retrieved August 3, 2010, from http://www.facebook.com/search/?post_form_id=2f75c829056bb647762f2b6f59ac8d8f&q=lowering%20the%20music%20when%20looking%20for%20a%20street%20address%20so%20I%20can%20see%20better&init=quick&sid=0.3228894266721488.

Fan, J. & Posner, M. I. (2004). Attention as an organ system. In J. Pomenrantz (Ed.), *Neurobiology of perception and communication: From synapse to society the IVth De Lange conference.* Cambridge, UK: Cambridge University Press.

Feaganes, J., Gish, K., Hamlett, C., Reinfurt, D., Rodgman, E., Staplin, L., & Stutts, J. (2005). Driver's exposure to distractions in their natural driving environment [Abstract]. *Accident Analysis & Prevention, 37*(6), 1093-1101.

Fernandez-Duque, D. & Posner, M. I. (2001). Brain imaging of attentional networks in normal and pathological states. *Journal of Clinical and Experimental Neuropsychology, 23*(1)*,* 74-93.

Field, A. (2005). *Discovering Statistics Using SPSS* (2nd ed.). London, UK: Sage Publications Ltd.

Forzano, L. B. & Gravetter, F. J. (2006). *Research Methods for the Behavioural Sciences* (2nd ed.). California, USA: Wadsworth/Thomson Learning.

Foxcroft, C. & Roodt, G. (2005). *An Introduction to Psychological Assessment in the South African Context* (2nd ed.). Cape Town, SA: Oxford University Press.

French, D., Irving, A., Kemp, R., West, R. & Wilding, J. (2006). Effect of low and moderate doses of alcohol on driving hazard perception latency and driving speed [Abstract]. *Addiction, 88*(4), 527-532.

Galotti, K. M. (2004). *Cognitive Psychology: In and Out of the Laboratory* (3rd ed.). California, USA: Wadsworth/Thomson Learning.

Geringer, J. M. & Nelson, J. K. (1979). Effects of background music on musical task performance and subsequent musical preference. *Perceptual and Motor Skills, 49*, 39-45.

Goodhill, V., Lambert, P. R. & Shulman, J. B. (2000). Acoustic and noise-induced hearing loss. In R. F. Canalis & P. R. Lambert (Eds.), *The ear: Comprehensive otology* (pp. 773-783). Philidelphia, USA: Lippincott, Williams & Wilkens.

Grahn, J. A. (2009). Neuroscientific investigations of musical rhythm: Recent advances and future challenges. *Contemporary Music Review, 28*(3), 251-277.

Hallam, S. & Schellenberg, E. G. (2005). Music listening and cognitive abilities in 10- and 11- year olds: The blur effect. *New York Academy Sciences, 1060,* 202-209.

Hargreaves, D. J. & North, A. C. (1999). Music and driving game performance. *Scandinavian Journal of Psychology, 40,* 285-292.

Hargreaves, D. J. & North, A. C. (2008). *The Social and Applied Psychology of Music.* New York, USA: Oxford University Press.

Heinz, S. P. & Johnston, W. A. (1978). Flexibility and capacity demands of attention. *Journal of Experimental Psychology: General, 107,* 420-435.

Herron, D. (2010). *Lowering the volume: Efforts to crack down on loud car stereos.* Retrieved July 26, 2010, from http://www.articlesbase.com/cars-articles/lowering-the-volume-efforts-to-crack-down-on-loud-car-stereos-1880360.html.

Heyduck, R. G. (1975). Rated preference for musical composition as it relates to complexity and exposure frequency. *Perception and Psychophysics, 17,* 84-91.

Hodges, D. A. (Ed.) (1996). *Handbook of Music Psychology* (2nd ed.). San Antonio, TX: IMR Press.

Husain, G., Schellenberg, E. G. & Thompson, W. F. (2002). Effects of musical tempo and mode on arousal, mood and spatial abilities [Abstract]. *Music Perception, 20*(2), 151-171.

It's your health. (2010). Personal stereo systems and the risk of hearing loss. Retrieved July 27, 2010, from http://www.hc-sc.gc.ca/hl-vs/alt_formats/pacrb-dgapcr/pdf/iyh-vsv/life-vie/stereo-eng.pdf.

Johnston, W. A. & Strayer, D. L. (2001). Driven to distraction: Dual-task studies of simulated driving and conversing on a cellular telephone [Abstract]. *Association for Psychological Science, 12*(6), 462-266.

Joseph, R. (2000). *Neuropsychiatry, Neuropsychology, Clinical Neuroscience*. New York, USA: Academic Press.

Kahneman, D. (1973). *Attention and Effort.* New Jersey, USA: Prentice Hall.

Kiger, D. M. (1989). Effects of music information load on a reading comprehension task. *Perceptual and Motor Skills, 69*, 531-534.

Konečni, V. J. & Sargent-Pollock, D. (1976). Choice between melodies differing in complexity under divided-attention conditions. *Journal of Experimental Psychology: Human Perception and Performance, 2*(3), 347-356.

Lagarde, E. (2007). Road traffic injury is an escalating burden in Africa and deserves proportionate research efforts. *PLoS Medicine, 4*(6), 967-971.

Large, E. W. & Palmer, C. (2002). Perceiving temporal regularity in music. *Cognitive Science, 26,* 1-37.

Lee, J. D. (2007). Technology and teen drivers. *Journal of Safety Research, 38*, 203-213.

Mathews, M. (1999). The ear and how it works. In P. R. Cook (Ed.), *Music, cognition, and computerized sound: An introduction to psychoacoustics* (pp. 1-10). Cambridge, MA: MIT Press.

Mesulam, M. M. (2000). *Principles of Behavioural and Cognitive Neuropsychology* (2nd ed.). New York, USA: Oxford University Press.

Meyer, L. B. (1956). *Emotion and Meaning in Music.* Chicago, USA: University of Chicago Press.

Mirsky, A. F. (1996). Disorders of attention: A neuropsychological perspective. In G. R. Lyon & N. A. Krasnegor (Eds.), *Attention, memory and executive function* (pp. 71-96). Baltimore: Paul H. Brookes.

MIT Open Courseware. (2009) .Rhythm: Patterns of events in time. . Retrieved November 26 2010, from http://ocw.mit.edu/courses/health-sciences-and-technology/hst-725-music-perception-and-cognition-spring-2009/lecture-notes/MITHST_725S09_lec16_rhy.pdf.

Moon, B. (2010). *Classifying music and musicians: What genre is that?* Retrieved April 11, 2010, from http://www.isnare.com/?aid=222502&ca=Entertainment.

Mussulman, J. A. (1974). *The Uses of Music.* Englewood Cliffs, NJ: Prentice-Hall.

Norman, D. A. (1968). Toward a theory of memory and attention. *Psychological Review, 75,* 522-536.

Patel, A. D. (2008). *Music, Language, and the Brain.* New York, USA: Oxford University Press.

Pickles, J. O. (1982). *An Introduction to the Psychology of Hearing.* London, UK: Academic Press.

Plack, C. J. (2004). Auditory perception. *Psychology: An International Perspective,* 1-19.

Pretorius, T. B. (2007). *Inferential Data Analysis: Hypothesis Testing and Decision-making.* Wandsbeck, SA: Reach Publishers.

Public Health. (2008). Personal music players and hearing. Retrieved August 3, 2010, from http://ec.europa.eu/health/opinions/en/hearing-loss-personal-music-player-mp3/l-2/2-sound-measurement-decibel.htm.

Selkirk, E. O. (1984). *Phenology and Syntax: The Relation between Sound and Structure.* Cambridge, MA: MIT Press.

Shaffer, D. R. (2002). *Developmental Psychology: Childhood and Adolescence* (6th ed.). Belmont, USA: Wadsworth/Thompson Learning.

Shoji, H., Takagi, K., Yamamoto, T., & Yoneada, H. (1970). Critical band width with respect to temporary threshold shift. *Journal of the Acoustical Society of America, 48,* 978-987.

Sloboda, J. (2005). *Exploring the Musical Mind: Cognition, Emotion, Ability, Function.* New York, USA: Oxford University Press.

Thaut, M. H. (2005). Rhythm, human temporality, and brain function. In Hargreaves, D .J., MacDonald, R. & Miell, D. (Ed.). *Musical Communication,* (pp.171-191). New York, USA: Oxford University Press.

Treisman, A. M. (1960). Contextual cues in selective listening. *The Quarterly Journal of Experimental Psychology, 12,* 242-248.

Whitley, B. E. (2002). Principles of Research in Behavioural Science (2nd Ed.). New York, USA: McGraw-Hill.

Wikipedia. (2010). Music cognition. Retrieved November 24, 2010, from http://en.wikipedia.org/wiki/Music_cognition.

Yates, G. K. (1995). Cochlear structure and function. In B. C. J. Moore (Ed.), *Hearing* (pp. 41-74). San Diego, CA: Academic Press.

Appendix A

Consent and information form prior to onset of the study

My name is Henriëtte Venter and I am a Masters Postgraduate student in Research Psychology at UNISA. I appreciate that you are volunteering your time to partake in the study.

This study aims to measure concentration and its influence on driving ability. Please note that all information and data obtained will be treated with strict confidentiality and anonymity is insured. If for any reason personal information is requested by someone not personally involved in the study, prior permission will be obtained before releasing such information or data. Information obtained during this study will be used for research purposes only.

I, the participant, confirm that I have been given instructions what is required from me with sufficient time left to do them; that is acquiring an adequate nights sleep. I have done that which is requested to my full capability. Before the onset of the study complete instructions will be given in order to assure that a clear understanding of the task is understood. In the first part of the study, a practice session will take place in order to assure that you are able to perform the second part of the study to your full ability. The second part of the study will take place under the same conditions but on a different track in different conditions.

If at any time during the study you feel that you are unable to continue due to any reason please inform me in order to stop the study immediately. If you feel that you are unable to continue you are free to leave without any negative consequences as a result of your withdrawal. Please sign below to give consent that you are willing to voluntary partake in the study indicated above if you decide to do so.

If you have any other questions after partaking in the study please feel free to contact me. My e-mail address is hvresearchproject@gmail.com.

If you are partaking in the research study please indicate this by signing below:

I hereby agree to participate in the research study regarding concentration and driving ability. I understand that I am participating on a voluntary basis, out of free will and without being forced in any way to do so. I also understand that I can stop or withhold my participation in the study at any point should I not want to continue, and that this decision will not affect me negatively in any way.

I, the participant, understand that this is a research study whose purpose is not necessarily to benefit me personally; whether it is in the form of remuneration or the results being applicable to me or not. I have been informed that my answers and the results obtained because of my participation will remain confidential.

……………………………..   ……………………………..

Name & surname   **Signature of participant**

Date: ……………………..…….

(Bauer, T. 2009 and http://www.hsrc.ac.za/Corporate_Information-49.phtml).

Appendix B

General information (given before questionnaire)

1. Thank you again for volunteering your time to participate in this research study.
2. Please note that all your information obtained remains confidential & no personal information will be shared without prior consent.
3. Before the onset of the practical side of the study I am going to hand out a questionnaire which you must please complete in as much detail as possible.
4. This questionnaire is purely for statistical use.
5. No information obtained at any time will be used for personality behaviour analysis or cognitive potential.
6. This study purely observes your driving behaviour under certain conditions.

Instructions (given before the practise session)

1. During the practice session you are allowed to ask as many questions about anything that is unclear or that you are uncertain about. However, when the actual study commence, no questions are allowed.
2. The practice session will last for a duration of 15 minutes.
3. The practice session will not be observed or recorded as it is included to give you the opportunity to get use to driving in this manner.
4. After the 15 minutes elapse you will receive a 10 minute break.
5. The actual study will commence after the break.

6. During the practice session and the actual study, your aim is to remain on the striped blue line displayed on the screen in front of you as far as possible. You will be able to practice this when completing the practice session.
7. You must try to complete a lap as fast a possible although more importantly attempting to be as accurate as possible when driving on the striped blue line.
8. It is advised that you do not exceed the speed limit of maximum 80km as this will produce the most reliable results for this study, due to possible unfamiliarity of the testing equipment. Speed may affect your ability to stay on the striped blue line.
9. Do not let the presence of the researcher observing behind you influence the way you behave. If you find this distracting, think of the researcher as a back seat passenger.
10. You are encouraged to drive the way you normally would as if you were in a normal driving situation. This includes the way you behave and how you position yourself when in an actual car.

Some practical instructions

1. You are driving the car in automatic transmission; therefore there is no need to be concerned with gears.
2. To make you familiar with the pedals, the gas is on your right and the breaks are on your left.
3. If you find yourself in a situation where you have to reverse, press the top left-hand button, as pointed out to you, and hold it in.

4. You do not need to be concerned with any other of the buttons or levers as the researcher will ensure that you start at the right point with the start of every condition.
5. If you see the striped blue line turning into a solid red line when approaching a corner, that is an indication that you are approaching that corner too fast. You therefore need to decrease the speed you are travelling at in order to make the corner.
6. The speedometer is at the bottom left hand side; please make use of this to control the speed you are travelling at.
7. In order to perform optimally it is advised that you familiarise yourself with these key points and ask the researcher if there is anything that you do not understand, or would like further explanation on.

Reminder after practise session and break before the actual study commence

1. It is important remember that you complete as many laps as you can, as fast as possible however, bearing in mind that it is more important to be as accurate as possible.
2. Do you have any other questions or concerns before we begin?
3. Are you ready to start?
4. Let's begin.

Appendix C

Questionnaire prior to participation in the study

PLEASE NOTE: All identifying and personal information obtained from the questionnaire is for statistical use only.

Name: …………………………………………………………………………………....

Surname: ………………………………………………………………………………...

Age: ……………………..……………………………………………………………….

Gender: (Please tick appropriate box)

Male Female

Race: ....

Position held at UNISA: ....

Do you have any prior gaming experience, specifically referring to Playstation 3?

YES NO

If yes, please specify how much experience you have? ....

Please indicate any other gaming experience you may have and the extent of that experience. Excluding Playstation 3: ....

1. In which year have you obtained your drivers licence? ....
2. How many years have you been driving in total (since you have legally obtained your drivers licence)? ………………………………..…………………….....

3. Has the researcher informed you well in advance to obtain a good nights rest consisting of minimum 7-8 hours sleep the night before your participation in this study? YES or NO? ……………………...…………………………….....………

4. Did you follow the instructions provided by the researcher? YES or NO?...........

5. How many hours of sleep did you obtain last night? …………………..................

6. On a scale of 1 to 10, how happy are you today? (1 = extremely unhappy, 10 = extremely happy) ……………………………....…………………………………

7. Please provide one word to describe the mood you are in today? ……………………………………………………………………………………….

8. How do you usually behave when you are in the mood that you are in today, specifically referring to driving behaviour? …………………………………..……. ……………………………………………………………………………….………… ……………………………………………………………………………….......... ..…………………………………..…………………………………………………..

9. Do you listen to music when you are driving, YES or NO? ……………….........

10. What type of music do you usually listen to when driving? …………….............. ....

11. Do you sometimes change from this type of music to another type of music, YES or NO? ………………………………………………………........................

12. If yes to answer 11, under which conditions do you usually change from one type to another? ……………………………………………….....…………….... …………………………………………………………………….……................. …………………………………………………………………………..............

13. Do you sometimes experience that listening to music influences your concentration while driving? On a scale from 1 to 5 indicate the number that best reflects your answer, 1 being *never* and 5 being *always* …………………….....
14. Referring to your answer in question 13, in which cases do this usually happen?

    …………………………………………………………………………………………….

    …………………………………………………………………………………....………

    ……………………………………………………………………………………………

    ……...……………………………………………………………………………….....
15. For you personally, what type of music that you hear creates a feeling of uneasiness or restlessness within you that may lead to a change in driving style or behaviour? …………………………...

    …………………………………………………………………….....................................

    ....……………………………
16. Why do you think this happens? ……………………………………………….

    ....……………………………………………………………………………………….

    ..……...

    ....

Thank you for volunteering to participate in the study, your cooperation is appreciated!

Appendix D

Observation scoring sheet

	Control			Low			Medium			High		
Order of Conditions	1											
Total laps Completed												
	Time per lap	**Error**	**Observed Behaviour**	**Time per lap**	**Error**	**Observed Behaviour**	**Time per lap**	**Error**	**Observed Behaviour**	**Time per lap**	**Error**	**Observed Behaviour**
Participant ... *Identifying details:*												