THE INFLUENCE OF EMOTIONAL STIMULI AND COGNITIVE LOAD ON DECISION MAKING CAPACITY

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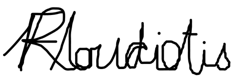
DECLARATION

I, Rochelle Elsie Floudiotis, hereby declare that this dissertation is my own work and that, where applicable, every effort has been made to correctly reference the work of other authors. Furthermore, I declare that this dissertation is to be submitted to the University of Pretoria and has not previously been submitted to this university or any other tertiary institution.

Signed this 12 day of 12 2018



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Abstract

The Cognitive Load Theory states that as cognitive load increases, cognitive resources available to complete a task become limited and hinders the successful completion of that task. It is similar for emotional arousal where the higher the level of emotional arousal, the longer it takes to complete a task. This research study explored the impact of cognitive load and emotional arousal on a decision making task, namely the Stroop task. Decision making was operationalised as the reaction time of responses (in milliseconds) during the Stroop task. Pupil dilation was used to measure varied levels of cognitive load and emotional arousal. The research adopted a quantitative factorial research design. Participants were sampled using convenience sampling, which resulted in a final sample size of 12 participants. To test the impact of cognitive load and emotional arousal on decision making, participants were exposed to a computerised version of the Stroop task. Data was analysed using a repeated measures ANOVA. Results indicated that there was a statistically significant difference between high and low levels of emotional arousal and reaction time. Additionally, the difference in pupil dilation between levels of high cognitive load and low cognitive load was statistically significant. Furthermore, there was a significant interaction effect between cognitive load and the time at which the stimulus was presented.

Keywords:

Cognitive Load Theory, cognitive load, emotional arousal, decision making, pupil dilation, Stroop task, convenience sampling, factorial design, reaction time, quantitative research.

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CHAPTER ONE
OVERVIEW OF THE STUDY

1.1 Introduction

This chapter explores the research problem and the rationale for the present research. The aim and objectives of the study will be discussed followed by an overview of the research methodology. The adopted theoretical framework will also be presented. This chapter functions as an introduction and overview of the report in its entirety and will conclude with a short discussion of the structure of it.

1.2 Research problem

Technological advances have created media that requires people to activate more than one sense modality to process the meaning of a message. For successful processing of an incoming stimulus to take place, Baddeley (2003) identified two channels, namely the audio and visual channel. The audio channel, referred to as the phonological loop, is responsible for processing information that has been heard. The visual channel, referred to as the visuospatial sketchpad, processes information in a visual form. Both these channels process different types of information (visual and auditory), but need to work together to form a complete message that makes sense. Even though processing a message is done via two separate channels, both the phonological loop and the visuospatial sketchpad are necessary to make sense of the meaning of the message, making it a multimodal process. (Baddeley, 2003; Marks, Ben-Artzi, & Lakatos, 2003).

The impact of media on modern society has increased due to easier accessibility and has been found to play a role in many areas of human development (Wartella et al., 2016) including cognition, everyday functioning, behaviour and social-learning (Anderson & Bushman, 2002; Krcmar & Cingel, 2014; Lillard & Peterson, 2011; Mares & Acosta, 2008). This does not only apply to adults, but to children as well because technology (tablet gaming, online streaming, etc.) has become their reality from a young age (Krcmar & Cingel, 2014; Lillard & Peterson, 2011). While still in school, however, most children live with their legal guardians and their identities and beliefs are still largely influenced by those who take care of them (Mares & Acosta, 2008). When children leave school and become university students, they become more independent and have free access to many forms of media sources. Any exposure to the media during this time of their lives may therefore not only impact their development, but their identities and belief systems as well (Aramide, Ladipo, & Adepoju, 2015; Jeong, Hwang, & Fishbein, 2010; Lairio, Puukari, & Kouvo, 2013).

Emotional stimuli in the media have become common; with a large portion being sexually related (Ward, 2003). Society has come to accept this sexual reality and have become accustomed to the sexual content found in all forms of entertainment and media (Parkes, Wight, Hunt, Henderson, & Sargent, 2013). This exposure has increased to such an extent that the content of movies, magazines and songs almost always includes sexual content or a sexual connotation (Jeong, et al., 2010; Kistler & Lee, 2009). As a result of this regular exposure, attitudes towards sexual content have transformed from taboo and forbidden into becoming an acceptable social norm (Manceau & Tissier-Desbordes, 2006).

The human mind has a limited capacity and when engaged in certain tasks, utilises this capacity accordingly (Kelley & Lavie, 2011). When exposed to an incoming message, an individual will, through selective attention, allocate available resources within that capacity to help process the message successfully. The more demanding, or difficult, the message is the more resources will be needed to process it. This applies for all cognitive processing (De AcedoLizarrage, De AcedoBaquedano, Oliver & Closas, 2009).

Decision making is a common cognitive process that is required for successful completion of tasks of varied difficulties. Easy tasks, like what to wear for the day, will demand fewer resources than more difficult tasks, like solving a mathematical equation. When faced with a message in the media where emotional stimuli already demand resources, cognitive capacity could be overloaded which reduces the amount of resources available for additional tasks, such as decision making (Parmentier, 2014). Emotional stimuli also results in the arousal of the cognitive system and as a result of this exposure, the cognitive system becomes aroused in addition to being loaded (Rieger & Savin-Williams, 2012). Even though these two constructs are different, where one involves emotional processing and the other is purely cognitive, they are often measured as a single construct using pupil dilation. This is an issue that the present study aims to address: in order to fully understand the relationship between external stimuli, cognitive load and emotional arousal, they would need to not only be viewed separately, but measured and reported on as separate constructs as well (Berggren, Koster, & Derakshan, 2012; Piquado, Isaacowitz, & Wingfield, 2010; Rieger & Savin-Williams, 2012).

1.3 Rationale

Decision making has been a popular topic of research in economic, industrial, neurological, consumer psychology and cognitive fields. Studying the nature of decision making is important as it allows for a greater understanding of the cognitive process that individuals engage in on a daily basis. Increasing this understanding not only benefits the field of science and psychology but will also provide valuable information about various decision-making tendencies (De AcedoLizarraga et al., 2009). Even though the proposed study will benefit the field of cognitive psychology, it also serves to inform individuals as to how their decision making may be influenced by their level of emotional arousal. When an individual is consciously aware of what may influence their decision, they may be able to recognise and, if preferred, eliminate that influence to ensure more effective decision making.

Despite the nature of a decision, albeit a mundane task like choosing what toothpaste to buy or a complex one like deciding what career to pursue, complex cognitive processing and allocation of resources is always necessary to complete a task. Kelley and Lavie's (2011) revision of Sweller's (1988) Cognitive Load Theory (CLT) states that not only is the task at hand and the individual engaging in the task influencers of cognitive load, but external environmental factors are as well. Therefore, changes in the environment, for example the presence of additional sexual stimuli, needs to be investigated in an attempt to fully understand cognitive load. The sexual reality of society is also a necessary domain to explore as it allows for a greater understanding of the functioning of modern society in their current reality: one that is openly more sexual and emotionally arousing than before (Kistler & Lee, 2009; Parkes et al., 2013; Ward, 2003).

Pupil dilation has been used to measure cognitive load and emotional arousal in many research studies who focus on either load or arousal (Berggren et al., 2012; Piquodo et al., 2010; Rieger & Savin-Williams, 2012), but little to no research has attempted to measure either construct separately in a single study. This research will attempt to do this and hopes to gain a greater understanding of the two separate constructs as cognitive processes during the research process.

1.4 Aims and objectives

The aim in the present research is to determine whether emotional stimuli and cognitive load have an impact on everyday decision making. More specifically, the present research aims to determine in what way, if any, cognitive load will be affected when paired with emotional stimuli of different intensity and whether that will influence how long it takes to make a decision. To achieve this aim, the following objectives have been set out:

- To determine how many participant responses during a decision making task, namely the Stroop task, are correct or incorrect.
- To measure reaction time (in milliseconds or ms) during the Stroop task when exposed to different levels of emotionally arousing words and cognitive loaded stimuli.
- To use pupil dilation (in millimetres or mm) as a measurement of varying levels of cognitive load and emotional arousal on separate and simultaneous occasions.

1.5 Description of methodology

The study has a quantitative, factorial design in order to measure decision making (measured by response time) when exposed to systematic manipulations of cognitive load and emotional arousal exclusively and then load and arousal combined.

Before the actual experiment begins, participants will be required to complete a colour blindness task, the Ishihara test, to ensure that colours can be correctly identified for the duration of the experiment. All participants are required to complete the Stroop task (Stroop, 1935) where words will pop up on a computer screen in different colours and they will be required to identify the colour of the font of the word on the screen by pressing the corresponding colour sticker on a keyboard. The experiment consists of six conditions that are designed to be manipulate cognitive load along two levels (low and high), and emotional arousal along three levels (low, mild, high). Words will appear on the screen eight at a time with a total of 60 words being presented. Participants will be given a practice trial of 8 words before commencement of the experiment.

The eye tracker, the measurement instrument for the study, will be fixed to the bottom screen of the laptop on which the experiment will take place. It will be on throughout the experiment. The purpose of the eye tracker is to provide physiological information on pupil dilation which is indicative of cognitive load and emotional arousal.

Due to the potentially confounding effect of age on cognitive development, a convenience sample was used for the experiment. All participants are recruited from the University of Pretoria and required to be between 18 and 28 years of age. A combination of repeated measures analysis of variance (ANOVA) was used for the analysis of the data. Statistical software programs SPSS and R were used to extract, organise and analyse data where significant main and interaction effects were tested for. A total of 12 participants volunteered and completed the experiment.

1.6 Theoretical framework

The study is situated within the cognitive paradigm where the human mind is viewed as a data-processing system. The cognitive paradigm emerged as a result of limitations of behaviourist approaches (Hebb, 1958, 1966; Miller, 1956). Behaviourism dominated the psychological field in the first half of the 20th Century and believed the scientific study of human behaviour could only be done through external and overt behaviour. As a result, the study of internal mental processes, such as decision making, was considered as unscientific (Lovie, 1983).

Cognitivists believed, contrary to behaviourists, that in order to understand a person and their actions, one needs to know how their mental processes operate. A theory that falls under the cognitive paradigm and conforms to that belief is the CLT. According to the CLT, an individual's cognitive system comprises of a broad long-term capacity and a limited working memory capacity (Brünken, Plass & Leutner, 2004; Hollender, Hofmann, Deneke, & Schmitz, 2010). Working memory (WM) and selective attention play a crucial role in task completion, especially under different cognitive load conditions (Lavie, Hirst, De Fockert, & Viding, 2004). An individual that is faced with a demanding task needs to allocate their available resources accordingly (Kelley & Lavie, 2011). This decision is influenced by the capacity of the cognitive system. When required to perform an action those resources are appropriately allocated to successfully complete the task. In this way, the mind is viewed as a data-processing and organising system.

Originally, CLT's theoretical framework was based on the premise that the individual engaging in a certain task and the task itself were the main causal factors of cognitive load (Van Merriënboer, Kester & Paas, 2006; Van Merriënboer & Sweller, 2005). A revised framework has introduced a new factor where the impact of the environment on cognitive load has also been emphasised. The input of the individual's physical environment during a task, in addition to the demand of it, imposes a load on an individual's working memory (Choi, Van Merriënboer, & Paas, 2014).

1.7 Structure of the mini-dissertation

Chapter one provided a brief overview on the background and approach of the study with specific focus on cognitive load, emotional arousal and decision making. The aims and objectives were presented. The CLT was introduced and situated within the cognitive paradigm where the role of cognitive load was placed in that of making a decision.

Chapter two provides a thorough review on the literature. This chapter explores present research and assists the reader in better understanding the constructs being studied in the present research. The literature review also discusses the differences and agreements of present research. Chapter two also includes the exploration of the theoretical and paradigmatic point of departure for the study which involved a brief discussion of the cognitive paradigm followed by an in-depth look at the assumptions of the Cognitive Load theory (CLT).

Chapter three informs the reader of the complete methodology of the research, including the chosen research design; the sampling procedures; apparatuses used; and experimental procedures of the study.

Chapter four reports on the results and findings of the study. All relevant statistical results and analyses are included in this chapter.

Chapter five provides a discussion on the findings where the results and literature were jointly discussed to draw inferences from the research. A brief discussion on the limitations of the study follows the discussion of the results. Recommendations for future research concludes chapter five.

Chapter five is followed by a complete reference list and several appendices with additional information. Information contained in the appendices includes what the researcher deems relevant as supplementary to the report.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the literature on decision making, cognitive load and emotional arousal. Literature on decision making theories and its process is presented followed by a detailed discussion of the cognitive paradigm and Cognitive Load Theory (Kelley & Lavie, 2011). More specifically, the role of selective attention in understanding cognitive load is focussed on. The study's paradigmatic and theoretical approach is discussed to situate the study's approach to reality and how the constructs are viewed throughout the study. According to present research cognitive load, decision making and emotional arousal have been found to interact with each other during information processing (Kistler & Lee, 2009; Parmienter, 2012). This interaction of constructs is also discussed according to what the literature says. Lastly, the operationalisation of pupil diameter and its association with cognitive load and emotional arousal are presented.

2.2 Decision making

Decision making has been a popular topic of research from as early as 1974 where Cohen and March described making a decision as a cognitive process that consists of four steps (Argyris, 1976). The process is as follows: an individual identifies and systematically orders objectives of the decision and then carefully explores all other possibilities of achieving those objectives. Once all the possibilities have been evaluated, a desirable choice or decision is made in attempt to reach some level of achievement (Argyris, 1976; Cohen & March, 1974). This understanding of decision making still holds true and is applied in many studies where the main idea of decision making involves choosing a desirable outcome based on a set of options (Murphy, Vandekerchove & Nieuwenhuis, 2014; Nayeem & Casidy, 2015).

Recently, decision making has been defined as a cognitive process that chooses a preferred option or a course of actions from a set of alternatives on the basis of given criteria or strategies (Wang, Wang, Patel & Patel, 2004; Wilson & Keil, 2001). Making a decision, a daily task, is a sequential process involving the gradual gathering of evidence in favour of each alternative (Murphy et al., 2014). The basis of that decision has been found to be influenced by the quality of evidence of what each choice offers (Murphy et al., 2014; Wang et al., 2004). An individual will make a decision that is viewed as the most beneficial within that context. Research has found that the accuracy of decisions, even under constant conditions, is variable (Murphy et al., 2014; Swami, 2013). This variability in decision making has been the focus of various research topics in the neurological, economic, financial, cognitive and consumer psychology fields where the general finding has been that decision making involves various neural and cognitive structures and that individuals tend to display certain decision making strategies (De Lange, Rahnev, Donner & Hakwan, 2013; Donner et al., 2007; Kelly & O'Connell, 2013; Nayeem & Casidy, 2015; Peterson, Kushwaha & Kumar, 2015). Murphy et al. (2014) state that the sources of the variability in decision making have not received much attention and serve as a challenge for the cognitive neuroscience studies of decision making.

Past experiences are also used, along with provided alternatives, when making a decision (De AcedoLizarraga et al.,2009). This can impact on the variability of decision making as individuals have different experiences, making their preferred option or course of actions also different (De AcedoLizarraga et al., 2009; Wang & Ruhe, 2007; Wang et al., 2004).

How humans perform in decision making tasks has been a subject of research from numerous perspectives (Swami, 2013). From a psychological perspective, it is necessary to evaluate how an individual makes a decision in terms of their needs and preferences. From a cognitive perspective, the decision making process needs to remembered as a mental process that is continuously interacting with the environment. From a normative perspective, the study of decision making is concerned with the logic and rationality thereof and the choice that it leadsto.

Decision making is therefore an imperative cognitive process of human beings that is widely used in various fields of research and is viewed as making the most desirable choice when presented with a set of possible outcomes (Cohen & March, 1974; Nayeem & Casidy, 2015). It has been viewed as a reasoning or emotional process (insinuating that it can be rational or irrational) that is used in almost every procedure of everyday life and is a basic mental process that occurs every few seconds either consciously or unconsciously (Swami, 2013; Wang et al., 2004; Wang & Ruhe, 2007).

2.2.1 Theories of decision making

Until recently, the study of eye movement and the role it plays in decision making has been minimal (Orquin & Loose, 2013). Only a few studies have attempted to explain and compare the theories of decision making and how eye movement can account for making decisions in various contexts (Fiedler & Glöckner, 2012; Glöckner & Herbold, 2011; Orquin & Loose, 2013). The following section is a brief discussion of four main decision making theories and their assumptions, with the aim of showing how decision making is theoretically viewed and understood.

2.2.1.1 Rational models

The rational or neoclassical model of decision making makes few assumptions of decision making but does make assumptions of information use- the main one being that human beings base their decisions on full and relevant information (March, 1978; Simon, 1955). A decision is made by fully attending to all the relevant information and that no internal or external factors are integrated throughout the process (Orquin & Loose, 2013). No relevant information is ignored. Another important assumption made by rational models is that decisions reflect individual preferences and that these preferences remain stable, suggesting that there is a relationship between choice and preference (Orquin & Loose, 2013).

2.2.1.2 Bounded rationality models

Herbert Simon (1957) challenged the rational models by introducing cognitive capacity limitations. Simon (1957) argued that the assumption about the use of all relevant information when making a decision cannot be true when those making the decision are in an environment that precedes their cognitive capacity. Instead, bounded rationality models suggest that decision makers approach a decision by selecting the information in a prioritising fashion to which they will attend (Orquin & Loose, 2013). This is done by selecting a favoured decision making strategy or mental shortcut, known as a heuristic (Orquin & Loose, 2013; Simon, 1957). There are several types of heuristics that are learned and developed over time and with experience. When it comes to acquiring information to make a decision, heuristics have been found to outperform rationality models, however this is only true for certain decision making tasks mainly under time pressure (Gigerenzer & Goldstein, 1996; Payne, Bettman & Johnson, 1988). The introduction of heuristics allowed bounded rationality models to provide an answer as to how individuals make accurate decisions with limited cognitive capacities (Orquin & Loose, 2013). Many researchers have posed the question:

How does an individual making a decision select between various heuristics? Despite various views, the most dominant answer is that a heuristic is chosen based on a trade-off between accuracy and effort (Beatch & Mitchell, 1978; Gigerenzer & Goldstein, 1996; Orquin & Loose, 2013).

2.2.1.3 Evidence accumulation models

Evidence accumulation models assume that, during decision making, individuals accumulate evidence in favour of the one alternative that they have been fixating, or focussing, on (Busemeyer & Townsend, 1993; Orquin & Loose, 2013). Instead of prioritising information as with bounded rationality models, evidence accumulation models assume that whatever the decision makers choose to focus on, that is where the most information will be gathered. The decision is made when the accumulated evidence has reached its threshold for one of the alternatives in a sequential manner (Busemeyer & Townsend, 1993; Ratcliff & Smith, 2004).

2.2.1.4 Parallel constraint satisfaction models

According to proponents of the parallel constraint satisfaction (PCS) model, decision making is an analytic process where information is gathered intuitively (Glöckner & Betsch, 2008). The PCS model consists of a dual process component namely the primary and secondary network. The primary network is activated first and is viewed as the neural network that represents the automatic processes of decision making (Glöckner & Betsch, 2008). Once the primary network is activated by the presentation of a decision problem, automatic processes operate towards establishing a consistent interpretation of activated information. In this way, different ways of interpreting the decision situation are weighed against each other, and the most probable interpretation is highlighted. The process results in a mental representation that guides decision making. In many everyday situations, and this proceeds completely automatically: a situation is perceived, a completely unconscious mental representation (primary network) is constructed and the favoured option is chosen. The secondary network is only activated when the individual's primary network fails to make an intuitive decision and consists of deliberate processes like explicit information search strategies (Glöckner & Betsch, 2008; Glöckner & Herbold, 2011).

All four of these theories are viewed as acceptable decision making theories (Orquin & Loose, 2013). The theory best applied to this study is the bounded rationality model where it is viewed that not all information can be processed when making a decision because the cognitive system has a limited capacity. Therefore, heuristics or mental shortcuts are used to make more accurate decisions using the least amount of cognitive effort in attempt to utilise available capacity effectively.

2.2.2 Variables associated with making a decision

Research on decision making initially focussed on the ability to predict how decisions are made and whether these decisions made in laboratory settings reflected how individuals make decisions in real life (De AcedoLizarraga et al., 2009). This manner of thinking has been criticised as limited and fails to explain how decisions are made in real, dynamic environments (Zsambok, 1997). A more naturalistic approach to understanding the process of decision making has been the focus of recent research where the context in which decisions are made and the role of personal competence and experience are emphasised (Cohen, 1995; Zsambok & Klein, 1997). Zsambok (1997) viewed decision making as a natural process and defined it as "the way people use their experience to make decisions in field settings" (p. 4). Maule and Maule (2016) argue that in order to be able to understand how a decision is made, laboratory based methods are more useful than field settings because it allows for optimal control throughout the experiment. However, De AcedoLizarraga and colleagues (2009) state that even though a laboratory offers more control than field settings, the environment in which the decision is being made cannot be ignored as an impacting factor.

Together with environmental demands, task and subject demands have been identified as variables associated with making a decision (Byrnes, 1998; Cannon-Bowers, Salas & Pruitt, 1996; Cannon-Bowers & Salas, 2002). Environmental demands define the context in which the decision is being made with specific focus on factors that are not part of the decision itself (e.g. social or work influences or distracting noises or occurrences). Task demands are associated with the nature of the task itself. For example, the approach to each alternative offered in the decision and whether there is a level of uncertainty, time pressure, consequences of the decision and quantity and quality of information. Subject demands, or "decision maker characteristics" (De AcedoLizarraga et al., 2009, p. 358), include the individual's internal factors: emotions that accompany the decision, expertise or experience in a certain area, motivation and the method of processing information.

According to these authors, these three variables need to be taken into account when studying decision making and are viewed as being highly associated with making a decision (De AcedoLizarraga et al., 2009).

2.3 Cognitive load

Cognitive load is a construct that has become very popular in psychological research with an increased interest in how it can be used to better understand cognitive processes and daily functioning (Van Merriënboer, & Sweller, 2005). Cognitive load is viewed in this study as a construct that can be best explained by the Cognitive Load Theory (CLT) which falls under the cognitivist understanding of social reality. Therefore, before cognitive load can be discussed, the broader approach to the study or its adopted paradigm needs to be explored. Additionally, the CLT also needs to be discussed to provide a theoretical explanation of cognitive load. The cognitive paradigm, focal points of the CLT as well as cognitive load and decision making are discussed below.

2.3.1. Cognitive paradigm

A paradigm has been defined as a scientific representation of reality and how that reality can be examined (Jordaan, 2014). Adopting a specific paradigm influences how the research and researcher views the world and how that knowledge should be gathered, interpreted and applied in order to understand reality.

The paradigmatic approach in this study was the cognitive perspective. According to Jordaan (2014), the cognitive perspective views the human mind as an information processing system that it functions like a high-speed computer which governs and influences behaviour through cognition. In other words, cognitivists view human beings as information processors whose actions are governed by their mental processes (Passer et al., 2009). A fundamental belief of the cognitive paradigm is that individuals are not passive observers of incoming stimuli from the external environment. Incoming information is manipulated by the cognitive system and actively processed in attempt to make sense of the world (Bernstein, Penner, Clarke-Stewart & Roy, 2006).

Adopting a specific paradigmatic approach directly affects the research and dictates how it is interpreted and understood. As a result, two important assumptions were made in this study. Firstly, the effects of cognitive load and emotional arousal on decision making may be measured and understood using cognitive theories and measures. Secondly, cognit ive processes like decision making are directly impacted by cognitive load and emotional arousal. Exposure to loaded and arousing stimuli of various intensities results in varied demands on an individual’s cognitive system (Van Merriënboer & Sweller, 2005) which is why the cognitive paradigm has been chosen to most effectively conceptualise the cognitive process of decision making that is at work when the cognitive system becomes loaded or aroused. This approach corresponds with that of previous studies, where a wide range of research has relied on the cognitive paradigm to study the effects of cognitive load and emotional arousal on decision making (De AcedoLizarraga et al., 2009; Maule & Maule, 2016; Van Merriënboer & Sweller, 2005).

The cognitive paradigm serves as an overarching conceptual framework to the CLT. This means that, as with any relationship between a paradigm and adopted theory, that the CLT is guided by the principles and views of reality of the cognitive theory (Jordaan, 2014).

2.3.2. The Cognitive Load Theory

One of CLT's main assumptions is that an individual's cognitive system comprises of a broad long-term capacity and a limited working memory capacity (Brünken, Plass & Leutner, 2004; Hollender et al., 2010). This capacity is utilised when action is required to process incoming information. Cognitive resources are allocated to incoming sensory information where it is processed and a task is completed. The more resources are needed to process information, the higher the load of that stimulus. The opposite is true for low load conditions. Selective attention and its two main mechanisms, namely the perceptual stream and attention control, as well as working memory all have an impact on cognitive load. All of these processes and mechanisms will be discussed in this chapter.

When exposed to any stimulus, the first thing the cognitive system does is process the incoming information. Information processing is an important cognitive process that needs to be done as fast and accurately as possible (Hazan-Liran & Miller, 2017). This cognitive process is the main focus of the CLT where the processing of sensory information, the mechanisms responsible for this processing and the different levels at which this processing occurs are focal points of the theory (Kelley, & Lavie, 2011). The CLT states that information processing, be it reasoning, planning, directing and maintaining attention, organization, abstract problem solving, self-regulation and motor control (referred to as executive functions collectively) all take up capacity in the already limited capacity cognitive system (Hazan-Liran & Miller, 2017; Kelly & Lavie, 2011; Brünken et al., 2004).

Information processing is required for a decision to be made, which in turn results in goal-directed behaviour. This requires selective attention to ensure that the correct information is being processed (Hazan-Liran & Miller, 2017; Lavie et al., 2004). Selective attention can formally be defined as the ability to attend to specific stimuli in the presence of irrelevant and distracting stimuli (Kahneman, 2011). A core assumption of selective attention is the existence of a filtering mechanism that allows for the discrimination between relevant and irrelevant stimuli (Hazan-Liran & Miller, 2017). There are two mechanisms, namely perceptual stream and attention control, that influence selective attention and play an important role in what information is processed (Lavie et al., 2004).

2.3.2.1 The perceptual stream

The perceptual stream is a passive mechanism and excludes irrelevant distracter stimuli from perception under conditions of high load which insinuates that when there is insufficient capacity for processing, distracters will not be perceived and no processing will take place (Kelley & Lavie, 2011; Lavie et al. 2004). There have been several debates as to when exactly the perceptual stream mechanism is influenced by sensory input and selective attention occurs, but the two main traditional approaches are: early selection theories and late selection theories (de Jager, 2015; Lavie et al., 2004).

Early selection theories. Early selection theories propose that information processing occurs sooner rather than later and that there is a filter in the cognitive system that operates at an early stage in the flow of information (Goldstein, 2011). This early operation results in the most important information that is perceived first to be processed first, eliminating any irrelevant and distracting stimuli (Goldstein, 2011). The unattended message or stimuli becomes blocked out completely because it was never perceived or registered in the first place. Selection of attended stimuli, therefore, happens early in the processing stream based upon their relevance to the performance of the task (De Jager, 2015).

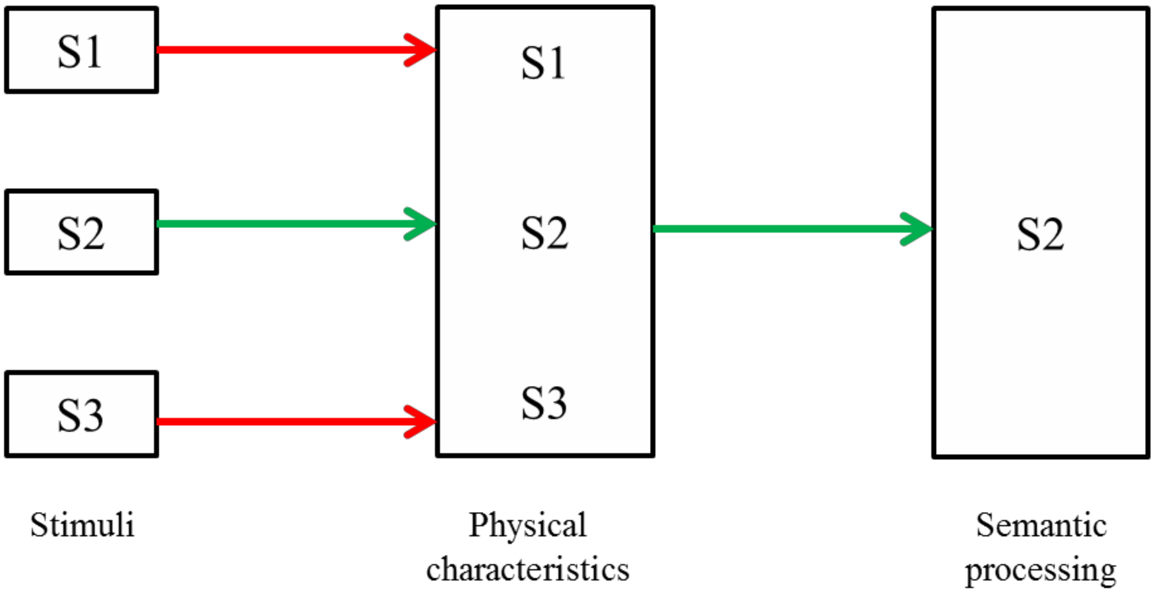


Figure 1. The filtering of perceived stimuli according to early selection theories. While stimulus one (S1) and stimulus three (S3) are processed for basic physical characteristics, only stimulus two (S2) is selected for further semantic processing (Goldstein, 2011).

This raises the questions of the ability to perceive multiple stimuli at the same time which, according to early selection theories, is not possible (De Jager, 2015). Early selection theorists explained this by stating that when multiple stimuli are attended to at the same time, the processing of the incoming stimuli will occur in a serial fashion, as illustrated in Figure 2.

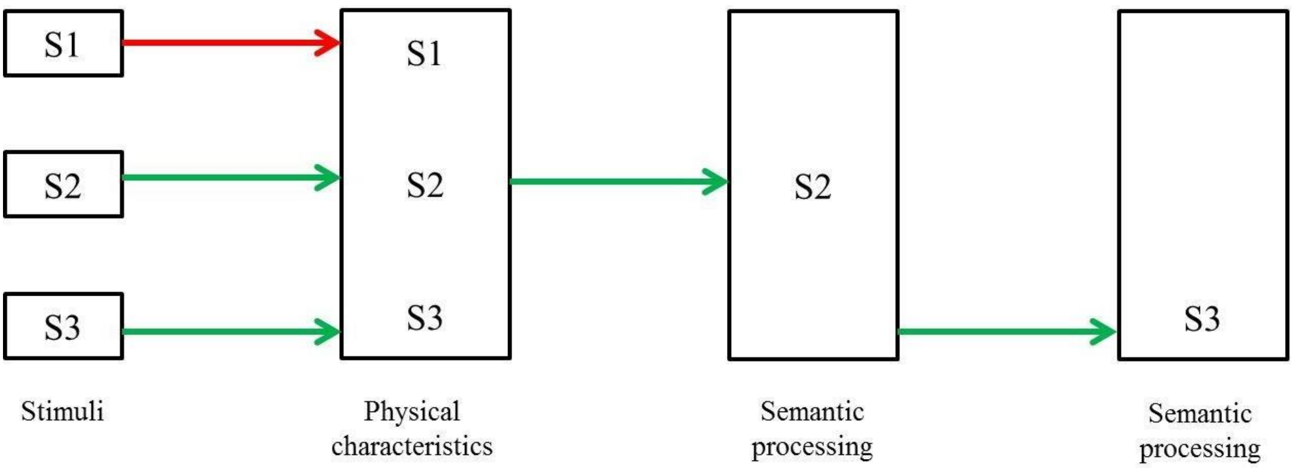


Figure 2. The filtering of perceived stimuli according to early selection theories when more than one stimulus is perceived. While stimulus two (S2) and stimulus three (S3) are

processed at the same time for semantic meaning, S2 is processed first and then only is S3 processed for semantic meaning (Pashler, 1998).

Late selection theories. Unlike early selection theories, late selection theories state that all incoming information is processed to the point of recognition and meaning, and only after that does filtering irrelevant information occur (Deutsch & Deutsch, 1963; Duncan, 1980). Late selection theories place as much importance on the processing of semantic meaning as early selection theories do on processing of physical characteristics (De Jager, 2015). Late selection theories maintain that only once a specific stimulus is deemed important does selection and filtering occur. This process has been illustrated in Figure 3 below.

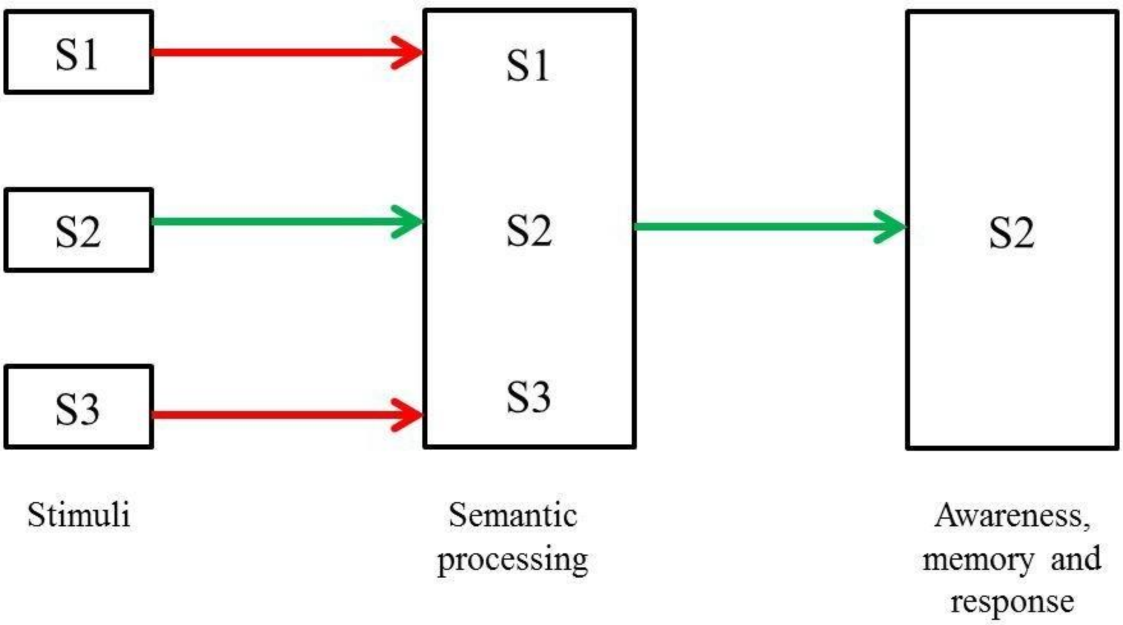


Figure 3. The filtering of perceived stimuli according to late selection theories when one stimulus is attended to. Regardless of which stimulus is attended to, all stimuli are processed for semantic processing. However, only the stimulus deemed most important will proceed to be available for conscious awareness and memory (Pashler, 1998).

As with any theoretical model, both approaches have some major limitations, the main one being that they both treat perception, semantic processing and physical processing as unchanging and inflexible (De Jager, 2015). Lavie (1995, 2001) has suggested a resolution to this debate and suggested the hybrid model of attention that combines aspects of both the early selection and late selection theories.

Hybrid model of attention. According to this model, irrelevant stimuli are excluded when the load in the processing stimuli (that which is task-relevant) is high and all available cognitive resources are utilised. This leaves little to no cognitive capacity available for the processing of any irrelevant or distracting stimuli. If in a situation where the cognitive load is low, there will be spare capacity left over from less demanding relevant stimuli which will then spill over to the processing of irrelevant stimuli. Therefore, early selection is predicted for high load situations, whereas late selection is predicted for situations of low load (Lavie, 2001; Lavie & Tsal, 1994).

A review of the previous selective attention studies provided support for this model (Lavie & Tsal, 1994). The experimental situations in the studies that provided support for late selection involved a low level of perceptual load (often with just one relevant and irrelevant stimuli present; e.g., see Gatti & Egeth, 1978), whereas the experimental situations in the studies that provided support for early selection could be generally characterized as carrying a higher level of load (e.g. with a greater number of stimuli present in the studies of Kahneman & Chajczyk, 1983; Yantis & Johnston, 1990).

Despite perceiving irrelevant stimuli in goal-directed behaviours, individuals with normal cognitive functioning are typically still capable of selecting the correct target response (Lavie et al., 2004). The ability to ensure an accurate response selection in situations of late selection in which both relevant and irrelevant stimuli are perceived must depend on some active control process that ensures that behaviour is appropriately controlled by goal-relevant stimuli rather than goal-irrelevant stimuli. This is where the second mechanism of selective attention takes over from the perceptual stream.

2.3.2.2 Attention control

During the engagement of a task or goal-directed behaviour, individuals are expected to process and perceive incoming information with the aim of making a decision or choosing between relevant tasks in order to achieve a certain goal (Goldstein, 2011). This requires effortful processing from the perceptual exposure to the stimulus up until semantic processing (Kelley & Lavie, 2011). The cognitive mechanism responsible for this effortful processing is working memory, and inevitably has an effect on selective attention (Hazan-Liran & Miller, 2017; Lavie et al., 2004).

Working memory. CLT posits working memory to be the underlying mechanism for dealing with current tasks (Artino, 2008). Working memory (WM) has been defined as the underlying mechanism of an individual's ability to learn (McCabe, Roediger, McDaniel, Balota, & Hambrick, 2010). Its central characteristic of having a limited capacity means that even though it can store about seven elements for a brief period, it has a processing capacity that is limited to only three to five elements at any given time (Cowan, 2001; Miller, 1956; Sweller, 1988, 1994). Moreover, it retains information for no more than a few seconds with almost all information lost after about 20 seconds, unless refreshed by rehearsal. When dealing with tasks or stimuli for which individuals have developed schemata and for which automatic processing takes place, WM capacity draws on long-term memory and its capacity and duration become limitless. Schemata (singular *schema*) refer to the pattern of thought that describes and organizes categories of information and the relationships among them (Goldstein, 2011). It is a cognitive framework of how an individual organises their world and a system of perceiving new information. Schemas can be useful because they allow us to take shortcuts in interpreting the vast amount of information that is available in our environment.

CLT begins to explain how in a situation where cognitive load is required, individuals would have developed the necessary schemata (i.e. mental framework) to organise and make sense of the incoming information (Sweller, 1988). For example, individuals are tasked to distinguish between the physical characteristics of a word and its semantic meaning as fast as they can. Some words are everyday words like "table" and "leaf" and other words are emotionally arousing like "love" and "suicide". It is expected of individuals to be able to identify the semantic meaning of the everyday words faster than the emotionally arousing words because their schemata for everyday words are easier to retrieve than the arousing words. The arousing words would demand more resources because it may take longer to retrieve the schemata related to those words compared to words that the cognitive system is exposed to everyday (Kousta, Vinson & Vigliocco, 2009).

Role of working memory in selective attention. Previous literature and experiments on WM load found no effect of WM load on the ability to efficiently search for task-relevant stimuli (Logan, 1978; Woodman, Vogel & Luck, 2001). Recently, WM has been manipulated during visual search tasks and it has been found that WM load specifically effects the way in which attention is captured by a single stimulus in a visual search task (Lavie et al., 2004). WM therefore steers the amount of mental effort being used to capture attention and attend to stimuli that an individual is being exposed to. It is a prominent mechanism involved in selective attention and making a decision as to what will be attended to and what will be viewed as irrelevant and ignored (Kelley & Lavie, 2011).

WM is viewed as the mechanism that maintains the distinction between relevant and irrelevant stimuli but can at times, because of its limited capacity, become overloaded and compromise the processing of necessary information (Lavie et al., 2004). Note, as mentioned earlier, that CLT emphasizes that such WM capacity and duration limitations are restricted to new information entering from sensory memory only (Sweller et al., 1998). WM therefore is the first cognitive mechanism that attempts to process information and plays an important role in contributing to the system's overall cognitive load as it filters relevant and irrelevant information to be processed (Kelley & Lavie, 2011).

2.3.3 Cognitive capacity

Cognitive load is the total amount of mental activity imposed on working memory at any given moment (Kelley & Lavie, 2011). As has been discussed, WM has a limited capacity and when it becomes overloaded, cognitive load is said to be high whereas when cognitive load is low, many cognitive resources are available to engage in goal-directed behaviour (Kelley & Lavie; Lavie et al., 2004). This is one of CLT's main assumptions. CLT differentiates cognitive load into three types: intrinsic, extraneous, and germane (Hazan-Liran & Miller, 2016).

2.3.3.1 Intrinsic and germane cognitive load

Intrinsic cognitive load (Sweller, 1994; Sweller & Chandler, 1994) is concerned with the natural complexity of information that must be understood and material that must be learned in order to fulfil a particular task. According to CLT, intrinsic cognitive load is determined by the number of elements that an individual has to process simultaneously in WM, with the number of elements is linked to the degree of element interactivity— that is, the availability and automaticity-of-retrieval of learned schemas stored in long-term memory for processing particular task-related information (Sweller, Van Merriënboer & Paas, 1998; Van Merriënboer & Sweller, 2005).

More specifically, dealing with stimuli or tasks for which the individual has no available or only insufficiently internalized schemas results in a high level of element interactivity and leads to high cognitive load (Sweller et al., 1998). If, for example, an individual is required to complete a task on a computer but have never worked on one before, their intrinsic cognitive load will be much higher compared to an individual who has worked on a computer many times before. This will result in a high intrinsic load meaning that more resources will be assigned to working on a computer than the given task.

In contrast, for an individual who deals with stimuli or tasks equipped with well-internalized schemas, element interactivity tends to be low, and consequently leads to reduced cognitive load (Sweller & Chandler, 1994). Thus, from a CLT perspective, schemas act as a central executive, organizing information or knowledge that needs to be processed in WM (Van Merriënboer & Sweller, 2005).

Intrinsic cognitive load originates from the interaction between the difficulty of the to-be-learned materials and the individual's expertise and is directly related to the task (Sweller, 2010). Intrinsic load is directly related to the task and is defined by the number and interactivity of elements that have to be processed (Sweller, 1988). In other words, for a given task, intrinsic cognitive load can only be altered by changing the nature of what is learned or by the act of learning itself because it is dependent on an individual's level of expertise (Sweller, 1994; Sweller, 2010; Sweller & Chandler, 1994).

Germane load is part of the intrinsic load of the task and has to do with making the task appropriately difficult for individuals so that the task is challenging and encourages encoding of new, learned information into long term memory (Hazan-Liran & Miller, 2017). Using the same example as above about computer usage, once the individual has used the computer for the first time, their germane load would have reached capacity and successfully encoded this new information into long term memory so that when they are required to use a computer again, they would be able to retrieve the encoded information and easily use a computer which, in turn, reduces intrinsic cognitive load and allows for more resources to be allocated to the task itself.

The relationship between intrinsic load and germane load is that the internal load focuses on the difficulty of the task and expertise and germane load is concerned with the assigned mental resources during a task to ensure that encoding into long term memory takes place (Sweller, Ayres & Kalyuga, 2011). Both intrinsic and germane load are mental resources that are devoted to learning and acquiring new information (Sweller, 1998).

A central idea of CLT, therefore, is to optimize intrinsic (level of difficulty based on expertise) and germane load (ability to encode into long term memory) (Sweller, 2010).

2.3.3.2 Extrinsic cognitive load

Variance in overall cognitive load, however, is often not only determined by task-intrinsic factors (amount of information units, availability of task-appropriate schemas, etc.)

but may be adjusted by the entry of task-irrelevant information into cognitive processes, resulting in extrinsic load (Van Merriënboer & Ayres, 2005; Sweller, 2010; Sweller et al., 2011; Sweller & Chandler, 1994). Extrinsic cognitive load occurs when WM becomes loaded with task-irrelevant stimuli that use mental effort (Sweller, 1998). For example, during an instructional computerised task, an individual cannot hear the instructor and starts to click on other icons on the computer screen, opening new programs. The focus on the newly opened programs is viewed as extrinsic cognitive load. Such an extraneous cognitive load adds to the overall cognitive load, and is hypothesized as being biased towards the processing of new materials, causing gains or losses in decision making, problem solving, and learning outcomes (Harp & Mayer, 1998; Van Merriënboer & Sweller, 2005; Rey, 2012).

Originally, CLT's theoretical framework was based on the premise that the individual engaging in a certain task and the task itself were the main causal factors of cognitive load (Van Merriënboer et al., 2006; van Merriënboer & Sweller, 2005). This framework did not consider the role of the external environment on cognitive load. A revised framework has recently included the impact of the environment on cognitive load. The input of the individual's physical environment during a task, regardless of its modality, imposes a load on an individual's WM (Choi et al., 2014).

2.3.4 Cognitive load and decision making

As stated earlier in this section, decision making is a process that requires an individual to choose between a set of alternatives based on a set of criteria or requirements (Cohen & March, 1974; Lavie et al., 2004; Swami, 2013). It is a cognitive process that is controlled by the executive functions of the mind (Swami, 2013). Executive functions are the management system of the mind that manages, directs, integrates and organises all incoming information (Hazan-Liran & Miller, 2017; Swami, 2013). The existence of a link between cognitive load and decision making has been suggested by numerous psychological studies (e.g. Del Missier, Mäntylä, & Bruine De Bruin, 2010; Hinson, Jameson & Whitney, 2003; Frederick, 2005; Shiv & Fedorikhin, 1999). However, these findings have been fragmented where the role of cognitive load on decision making has only been on a limited number of types of decision making tasks (Swami, 2013).

When required to make a decision, individuals need to make a choice between two or more stimuli (Lavie et al., 2004). The more difficult the decision, the more cognitive resources are allocated to the task in attempt to complete it (Kelley & Lavie, 2011; Lavie et al., 2004; del Missier, Mantyla, & De Bruin, 2012). This happens because a demand on cognitive resources limits the individual's ability to hold necessary information in memory while simultaneously trying to make an effective decision (Arce & Santisteban, 2006; Hatfield-Eldred, Skeel, & Reilly, 2015). A simple everyday decision like deciding what to have for breakfast requires less executive control which means that there is minimal demand on cognitive load and the task can be completed using fewer resources (Glöckner & Herbold, 2011; Swami, 2013). This will lead to behaviour where a decision has been made based on limited information (Del Missier et al., 2012).

2.4 Emotional arousal

Arousal broadly refers to an individual's state of responsivity when exposed to external stimulation and determines the way in which that individual will respond to their environment (Pfaff, Martin & Faber, 2012). The intensity or degree of responsivity of an individual is heightened when exposed to emotional stimuli which results in increased amygdala activity in the brain resulting in arousal (Kousta et al., 2009; Murphy et al., 2014). The amygdala plays an important role in regulating emotions as it perceives and processes emotional stimuli (Costafreda, Brammer, David & Fu, 2008). Higher levels of activation in the amygdala was found when individuals were exposed to emotional stimuli (for example, faces showing pain, sadness or anger) compared to neutral stimuli (apples, pencils and jackets), suggesting that emotional stimuli results in higher arousal than neutral stimuli (Costafreda et al., 2008).

There are some studies that suggest that negative emotional stimuli create more arousal than positive stimuli (Adolphs et al., 1999; Davis & Whalen, 2001; LeDoux, 2000a, 2000b; Schafe & LeDoux, 2004) but recent literature suggests that the valence of the stimulus is more important (Costafreda et al., 2008; Murphy et al., 2014). The valence of a stimulus is either the internal attractiveness (positive valence) or averseness (negative valence) of a stimulus (Costafreda et al., 2008). In their study on emotional processing, Kousta and colleagues (2009) found a significant effect of valence even when arousal was held constant and no effect of arousal when valence was held constant. This suggests that positive and negative emotional stimuli, when compared to neutral stimuli, have a significant impact on arousal and, more importantly, that the valence of a stimulus does not have a facilitatory effect on arousal, it stands alone as having a direct effect on it (Kousta et al., 2009: Murphy et al., 2014). Emotional words are also processed faster, regardless of valence, than neutral words (Kousta et al., 2009). Emotional arousal has been found to act as a distraction when engaging in other tasks where mental capacity is low (Shiv & Feodorikhin, 2002). The reason for this is that majority of the cognitive resources have been allocated to completing the task and as a result there are few resources available to regulate the impact of arousal on performing tasks (Van Dillen, Hoffman & Papies, 2013).

When it comes to the relationship between how well one performs and arousal, an "inverted-U" relationship explains it best (Murphy et al., 2014, p. 1). Moderate or mild levels of arousal increase focus and task engagement but as soon as arousal departs from this optimal state, an individual can become drowsy and demotivated on the one extreme or very distractible on the other extreme (Aston-Jones & Cohen, 2005; Easterbrook, 1959; Kahneman, 1973). This suggests that the ability to effectively complete a task, for example making a decision, may decline at a very low or very high state of emotional arousal (Murphy et al., 2014).

2.4.1 Emotional arousal and decision making

Most of the information there is about the impact of emotional arousal on judgements, choices and behaviour stems from personal or vicarious experience (Ariely & Loewenstein, 2006). Research that has been done on emotional arousal generally focuses on the impact of positive or negative emotional stimuli on decision making (e.g. Costafreda et al., 2008; Kousta et al., 2009; LeDoux, 2000a, 2000b; Murphy et al., 2014). Ariely & Loewenstein (2006) state that research on how taboo stimuli, for example sexually arousing stimuli, impacts decision making is minimal despite the importance of the topic. Taboo stimuli, as discussed in section 1.2 of this paper, have become a large part of modern society's everyday life and need to be the focus of future research to build on existing knowledge of its impact on everyday living (Jeong, et al., 2010; Kistler & Lee, 2009).

Studies that have focussed on emotional arousal and decision making have found that when required to make a decision, the reaction time was slower for positive and negative stimuli than neutral stimuli (Murphy et al., 2014; Kousta et al., 2009). In a study where sexually related stimuli and neutral stimuli were compared, Ariely and Loewenstein (2006) found that decisions were made at a slower rate when individuals were distracted by sexual stimuli compared to neutral stimuli. These findings all suggest that as levels of arousal increases, the time it takes to make a decision also increases.

Del Missier and colleagues (2011) state that decision making may rely more on emotion-related processes than one realises. For example, numerous studies have related performance in the Iowa Gambling Task (IGT) with the ability to regulate and anticipate emotions (e.g. Bechara, Damasio, Tranel, & Anderson, 1998; Bechara, Damasio, Tranel, & Damasio, 2005; Stocco & Fum, 2008). Even though researchers have attempted to link changes in emotional arousal to the consequences of decision making, this relationship is still poorly understood and requires attention in psychological research (Murphy et al., 2014).

2.4.2 Emotional arousal and cognitive load

As discussed in section 2.2.2 of this chapter, the CLT proposes when exposed to a stimulus, the cognitive system allocates resources to process that stimulus and as a result reduces the amount of resources available for processing additional information, extending that to emotional information as well (Berggren et al., 2012; Lavie et al., 2004). Exposure to emotional stimuli causes the aroused cognitive system to first process the emotional information and to depend on later cognitive influences (like executive functional control) to process incoming task-related information (Berrgren et al., 2012; Duncan & Humphreys, 1989).

In their study, Berggren and colleagues (2012) had participants complete a visual search task and asked them to press a key whenever human faces changed expression while simultaneously having to complete a basic maths problem on a computer screen. They found that emotional arousal has an impact on response time and explained that in conditions of high load and high arousal that the cognitive mechanisms responsible for allocating cognitive resources became overloaded and as a result caused slower response times (Berrgren et al., 2012). Parmentier (2014) agreed with these findings and stated that when the system becomes emotionally aroused by irrelevant stimuli, distraction occurs as attention constantly moves back and forth between what is relevant and what is not which triggers the involuntary processing of irrelevant stimuli and destabilises performance on the ongoing task.

2.5 Pupil dilation

Pupil dilation is the total diameter, in millimetres, of the pupil in the eye and the study of pupil dilation is referred to as pupillometry (Porter, Troscianko & Gilchrist, 2007; Rieger & Savin-Williams, 2012). Pupillometry has been the topic of psychological research from as early as 1964 where Hess and Polt showed that pupil dilation is accompanied by mental effort (Porter et al., 2007). A substantial body of early work has shown that the degree of dilation is indicative of the processing demands of a task (see Beatty, 1982, for a review). For example, Kahneman and Beatty (1966) showed that pupil size increased substantially when participants listened to a list of digits and presumably stored them in memory and then decreased when they were required to recall that information. Since then, pupillary response and pupil dilation has been used as a measure of cognitive effort or emotional arousal in numerous tasks (Beatty, 1982; Piquado et al., 2010; Porter et al., 2007). It is generally accepted that regardless of the nature of the task to be completed, whether numerical or linguistic, pupil size will increase as the level of difficulty of that task increases or when the system becomes aroused (Piquado et al., 2010).

Consequently, pupil dilation has been a popular measurement tool in psychological studies (Hyona, Tommola, & Alaja, 1995; Kahneman, 1973; Rieger & Savin-Williams, 2012). Literature does caution against the confounding effect of light in pupillometry (Porter et al., 2007; Riger & Savin-Williams, 2012). Because pupil dilation is an automatic process, the pupils will immediately dilate when exposed to any visual input regardless of its relevance to the task which means that initial luminance could interfere with the measurement of pupil size and therefore confound results (Porter et al., 2007; Rieger & Savin-Williams, 2012). This can be controlled for by ensuring that the lighting in the experimental setting stays constant throughout the entire experiment so that the visual input is the same for all conditions (Bradley, Miccoli, Escrig & Lang, 2008; Porter et al., 2007).

Using pupil dilation as a measurement tool for cognitive load and emotional arousal may have some challenges, but they can be controlled for and are far outweighed by the benefits of using it (Berggren et al., 2012). It is a measure that is an automatic process which means that practise effects or manipulation in answering cannot occur, it is similar across gender, age and language and therefore includes a wide range of individuals in its measuring and lastly, it has the ability to capture a wide range of responses as the pupil continuously dilates (Riger & Savin-Williams, 2012).

2.5.1 Pupil dilation, cognitive load and emotional arousal

The study of pupillometry and cognitive load is theoretically important because it relates to the involvement of memory in task engagement and completion (Porter et al., 2007). The role of emotional arousal and pupillary changes is one that needs to be explored as information regarding their relationship is limited (Bradley et al., 2008). The study of both these constructs is significant in psychological research, as discussed in sections 2.2 and 2.3, and can lead to a better understanding of what influences decision making.

The extent of pupil dilation is a reliable indicator of the level of processing demands of a task with larger dilation related to higher processing and utilising more cognitive resources (Porter et al., 2007). The same is true for emotional arousal where higher levels of emotional arousal result in increased pupil size (Ariely & Loewenstein, 2006; Bradley et al., 2008). Originally, pupil dilation was greater when an individual was exposed to negative emotional stimuli compared to positive stimuli (Libby, Lacey & Lacey, 1973). Recent studies have found this to be untrue, where exposure to emotional stimuli, regardless of valence, causes pupils to dilate (Bradley et al., 2008). This supports the idea that pupil dilation can be used to measure mental processing, but the problem is when exposed to an external stimulus, the cognitive system becomes both aroused and loaded at the same time. Therefore two processes, namely cognitive load and emotional arousal are often measured (using pupil dilation) and assumed to be a single construct (Berggren et al., 2012; Piquodo et al., 2010; Rieger & Savin-Williams, 2012). This assumption condenses two separate constructs into one process and as a result limits understanding of decision making when it comes to being exposed to a high load and emotionally intense stimulus in one task. There is a need to therefore separate arousal and load in attempt to better understand whether either construct is indeed exclusive in its influence on decision making or not.

2.6 Chapter summary

Decision making has been defined as a cognitive process of an individual who chooses a preferred option from a set of alternatives (Wang et al., 2004). Lizarraga et al. (2009) have added to that definition by stating that past experiences have an impact on how one makes a decision. Even though there a multiple decision making theories, the bounded rationality model has been applied to this study because of its assumption of a limited capacity cognitive system and that there is a constant trade-off between accuracy and effort when allocating cognitive resources to making a decision (Simon, 1957). When studying decision making, it is imperative to try understand all variables associated with the process, this includes the subject, the environment and the task at hand (Zsambok, 1997).

The CLT focuses on information processing whereby selective attention and working memory play a crucial role in task completion, especially under different cognitive load conditions (Lavie et al., 2004). Selective attention has been divided into two mechanisms; namely the passive perceptual stream and the conscious, active attention control mechanism. The attention control mechanism includes working memory which has a limited capacity when exposed to sensory input. An individual that is faced with many resources and is required to perform a task needs to decide where to allocate them (Kelley & Lavie, 2011). This decision is influenced by the capacity of the cognitive and working memory system. In high load conditions, individuals utilise a large amount of available resources which results in a limited capacity to process other information. The opposite is true for low load conditions.

WM is involved in the allocation of these resources and results in conscious attention which assists goal-directed behaviour (Lavie et al., 2004; Lavie & Kelley, 2011).

An individual becomes emotionally aroused when responsivity to external stimuli is heightened (Kousta et al., 2009; Murphy et al., 2014; Pfaff et al., 2012). Studies that have focussed on emotional arousal, including taboo stimuli, and decision making have found that when required to make a decision, the reaction time was slower for positive and negative stimuli than neutral stimuli (Murphy et al., 2014; Kousta et al., 2009). Previous literature therefore states that an increase in cognitive load or emotional arousal will result in a slower response time when compared to a low load or low level of arousal.

Pupil dilation is a reliable measure of cognitive load and emotional arousal (Beatty, 1982; Piquado et al., 2010). Consequently, pupil dilation has been a popular measurement tool in psychological studies (Hyona et al., 1995; Kahneman, 1973; Rieger & Savin-Williams, 2012). Even though light has been found to act as a confounder in pupillometry it can be controlled for by ensuring that lighting conditions in experimental settings remain the same throughout the experiment (Porter et al., 2007; Riger & Savin-Williams, 2012).

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter focuses on the methodology that is used in the present study. Choosing the most appropriate methodology is important as it guides the research. In other words, the approach the researcher takes in formulating the research question, collecting and analysing data collected, and the limitations are all linked to the choice of methodology. The methodology serves as a tool of guidance and clarity throughout the research.

When it comes to choosing the methodology, the researcher needs to decide which methodological approach is most appropriate in addressing the research and will provide sufficient evidence to support it. By reading relevant literature, it has become clear that the majority of previous work on cognitive load, emotional arousal and pupil dilation has been empirical in nature. Empirical data, gathered during experimental testing, can be used to better understand cognitive processes that are otherwise internal mental processes and difficult to directly observe.

Given the background and purpose of the study, a quantitative methodology was adopted. A quantitative methodology allows the researcher to use empirical data to test the hypotheses between the identified variables in the study. The ability, however, to draw valid causal inferences from the empirical data depends on whether three basic conditions have been met (Shadish, Cook & Campbell, 2002). First, the cause must come before the effect. Second, the cause and effect have to covary. Third, any other explanations for the results have to be ruled out. For this experimental study, it was important to keep the impact of mediating variables that could serve as alternative explanations for the results minimal. The reason for choosing to adopt an experimental design for the study will be further explained in the research design section of this chapter.

3.2 Research question, aim and objectives

The main aim of this study is to determine whether emotional stimuli and cognitive load have an impact on decision making. In alignment with the aim, the research question guiding the study is: What is the impact of emotional arousal and cognitive load on decision making?

3.2.1 Objectives and hypotheses

In order to achieve the aim, three primary objectives have been set out. The first objective is to determine how many responses are correct or incorrect during the Stroop task. The second objective is to measure the reaction times of the participants as they complete the Stroop task. The third objective is to record pupil dilation, in millimetres, of participants as they are exposed to different levels of cognitive load and varied intensities of emotional arousal. Decision making is operationalised as the reaction time of responses (in milliseconds) during the Stroop task. This will be discussed in the chapter presenting the results and analyses.

Given the factorial structure of the design, three hypotheses have been formulated to reflect main and interaction effects. These hypotheses are given below:

3.2.1.1 Reaction time (RT) hypotheses

1) The mean response time for low emotionally arousing words will be different from high emotionally arousing words:

$$H_0: \mu_{LowArousal} = \mu_{HighArousal} : H_1: \mu_{LowArousal} \neq \mu_{HighArousal}$$

2) The mean response time for low load words will be different from high load words:

$$H_0: \mu RT_{LowLoad} = \mu RT_{HighLoad} : H_1: \mu RT_{LowLoad} \neq \mu RT_{HighLoad}$$

3) There is a two-way interaction between emotional arousal and cognitive load for mean response time:

$$H_0: A - B = 0 : H_1: A - B \neq 0$$

$$\text{where } A = (\mu RT_{LowArousalLowLoad} - \mu RT_{LowArousalHighLoad}) \text{ and}$$

$$B = (\mu RT_{HighArousalLowLoad} - \mu RT_{HighArousalHighLoad})$$

3.2.1.2 Pupil dilation (PD) hypotheses

4) The pupil dilation for low emotionally arousing words will be different from high emotionally arousing words:

$$H_0: \mu PD_{LowArousal} = \mu PD_{HighArousal} : H_1: \mu PD_{LowArousal} \neq \mu PD_{HighArousal}$$

5) The pupil dilation for low load words will be different from high load words:

H_0: $\mu PD_{LowLoad} = \mu PD_{HighLoad}$: H_1: $\mu PD_{LowLoad} \neq \mu PD_{HighLoad}$

6) There is a two-way interaction between emotional arousal and cognitive load for pupil dilation:

$$H_0: A - B = 0: H_1: A - B \neq 0$$

$$\text{where } A = (\mu PD_{LowArousalLowLoad-}\ \mu PD_{LowArousalHighLoad}) \text{ and}$$

$$B = (\mu PD_{HighArousalLowLoad-}\ \mu PD_{HighArousalHighLoad})$$

3.3 Research design

This study has a quantitative, experimental design (Shadish et al., 2002). An experimental design has four defining features: (1) variables are measured to obtain a set of scores in a single or multiple treatment conditions; (2) scores obtained in one condition are compared with those obtained in another condition; (3) there is a strict form of control throughout the treatments to make sure that no other variables influence those that are being examined; (4) variables are manipulated by the researcher to create a set of multiple treatment conditions (Gravetter & Forzano, 2012).

When two or more independent variables are manipulated in a study, it becomes a factorial design and the independent variables are referred to as factors (Shadish et al., 2002). Due to manipulating both cognitive load and emotional arousal, this study has an experimental factorial research design where a 2 x 3 crossed design will be used for pupil dilation, reaction time and correct responses. This means that each level of each factor is exposed to all levels of the other factors. Even though this has been identified as a weakness because of the difficulty of manipulating more than one independent variable simultaneously (Christensen, Johnson & Turner, 2015), it is advantageous in this case as it allows for observation and testing of interactions of the independent variables on the dependent variable.

Using a crossed factorial experimental design is also advantageous because it allows for the combining of treatment conditions easily and meaningful interactions between the factors can be evaluated and traced (Shadish et al., 2002). Another advantage is that because all participants will be exposed to both factors on all three levels simultaneously, a smaller sample size is allowed.

Recall that the principle factors are: *cognitive load* (low load vs high load) and *emotional arousal* (low, mild and high). Cognitive load was characterised by the words and the colour that they are presented in. Low cognitive load contained words that are congruent with the colour of the ink the word is presented in (for example, the word RED is presented in red ink). High cognitive load contained words that are incongruent with the colour of the ink the word is presented in (for example, the word RED is presented in blue ink). Emotional arousal was characterised and manipulated by the emotional intensity of the word. Table 1 provides a summary of the different experimental conditions of this design. Each condition contains some form of cognitive load and emotional arousal. Each condition contains low, mild or high emotionally arousing words as well as low or high cognitive load words. Cognitive load was manipulated by using either congruent or incongruent words and emotional arousal was manipulated by using low, mild or high emotionally arousing words (this will be explained in section 3.5).

Table 1: Summary of the factorial experimental conditions

	Low Emotional Arousal	Mild Emotional Arousal	High Emotional Arousal	Low Cognitive Load	High Cognitive Load
A1 (Condition 1)	+			+	
B1 (Condition 2)		+		+	
C1 (Condition 3)			+	+	
A2 (Condition 4)	+				+
B2 (Condition 5)		+			+
C2 (Condition 6)			+		+

Note. A plus sign (+) indicates the presence of a factor in the treatment condition

3.4 Sampling

The utilisation of an appropriate and scientific sampling method is essential for obtaining valid results in research (Acharya, Prakash, Saxena, & Nigam, 2013). Even though different sampling methods have their own advantages and disadvantages, it is important to discuss issues regarding sampling to contextualise a study (Trochim, 2006). A discussion on the selection criteria for the sample, the sampling method and the sample now follows so that the findings of the current study can be contextualised.

3.4.1 Selection criteria

Participants are required to be between the ages of 18 and 28 years (due to cognitive developmental differences observed at different life stages) and must be able to give consent either orally or in a written format. For standardization purposes the entire experiment, instructions and all forms of communication will be presented in English. The participants will therefore have to have a basic proficiency in English. The study's focus on the ability of identifying the colour of words means that they cannot suffer from colour-blindness. Computer literacy is another requirement. A computerised survey will be submitted before the experiment occurs, confirming that participants are computer literate and do not suffer from neurological and cognitive problems (like epilepsy or ADHD) which may influence their performance. Any significant deficits in the ability to detect colours will be ruled out at the start of the experiment through the application of a version of the Ishihara colour-blindness test. Should participants display any significant deficits after completion of this test, they will not continue the experimental procedure.

3.4.2 Sampling method

This study adopted a non-probability convenience sampling strategy. This involves selecting individuals from a population where the parameters of that population are unknown (Gravetter & Forzano, 2012). Also, individuals from the population do not have an equal chance of being selected, increasing the chance of sampling bias. In attempt to counter for sampling bias, researchers often control for sample particulars by trying to ensure homogeneity of the sample along with specific particulars that are deemed important for the study (Harris, 2008). Although various factors like language usage, gender and computer usage tendencies may have acted as confounding variables and could have had a significant effect on participants' response times throughout the experiment, the narrow focus of the research question meant that not all factors could be controlled for in the study (De Jager, 2015).

Given the use of response rates as the dependent variable, the sampling strategy controlled for age as a possible confounding variable. The reason for this is because of the link between age and decrease in cognitive functioning (Yoder et al., 2010). Furthermore, it has been found that aging was associated with lower attention spans and slower response times when required to complete a task (Gooch, Stern & Rakitin, 2009). To therefore ensure that cognitive decline due to age is controlled for in the current study, the age range of eligible participants was limited to between 18 and 28 years of age. All participants had normal to corrected-normal vision and displayed no signs of colour-blindness following the completion of a shortened version of Ishihara's colour-blindness test (1972).

3.4.3 Sampling procedure

A total of 12 students from the University of Pretoria (UP) between the ages of 18 and 28 volunteered to participate in the study. An invitation to participate in the study was posted via the UP student portal (ClickUP) and included basic information about the study. The invitation also contained information on the selection criteria, as well as additional instructions for those students willing to be participants. It was through this invitation that participants volunteered to participate in the study. Those interested made contact with the researcher, indicating their voluntary participation. The researcher and each participant set up a suitable time and day for the experiment to take place. The time of experiment, for all participants, was limited to the morning in attempt to keep experimental conditions standardised.

Before the start of the experiment, the researcher reminded the participants that they may voluntarily withdraw at any time throughout the experiment with no punitive consequences. The participants were also reminded that some word stimuli may be explicit and if they feel uncomfortable as a result, that they may withdraw at any time. After obtaining written consent, the participant started the experiment. Table 2 reports the final sample obtained for the study in terms of age and gender.

Table 2: Summary of the sample demographics (n=12)

Age	Females	Males	Total
19 years old	34% (4)	-	34% (4)
20 years old	34% (4)	8% (1)	42% (5)
21 years old	8% (1)	-	8% (1)
22 years old	8% (1)	8% (1)	16% (2)
Total	10	2	12

The majority of the sample consisted of female participants (n=10) while only 2 male participants took part in the study. The sample was therefore heavily biased in terms of gender distribution. Forty-two percent of the sample consisted of 20 year old participants, with the youngest participant being 19 years of age and the oldest participant being 22 years old. This means that the sample was relatively homogenous in terms of age.

3.5 Data collection instruments

The instruments used in the current study are a computerised survey, the Stroop task and the eye tracker. The survey was used to collect demographical information (e.g. age and gender) and as a screening tool. The Stroop task was used as a measure for decision making where participants will respond to certain stimuli. Finally, the eye tracker was used to measure pupil dilation which, as discussed in chapter two, is indicative of cognitive load and emotional arousal.

3.5.1 Computerised survey

To ensure that the participants did not suffer from any neurological or cognitive conditions that could be triggered by the experiment or could influence their performance (e.g. epilepsy), a computerized survey was created that would be filled in before the start of the actual experiment. The survey also formed as a way of collecting participants' demographical information and checked that they were computer literate.

The survey consisted of two sections. The first section gathered demographical information from participants, such as their age and gender. The second section dealt with participants' exposure to computers, laptops, etc. and how comfortable they felt in working on computers.

3.5.2 Colour blindness

Because of the nature of the Stroop Task and the need to identify colours on a computer screen, a colour-blindness test was to be completed before the experiment commenced. This test was done following the successful completion of the computerized survey. The Ishihara colour-blindness test, first published in 1917 by Shinobu Ishihara, is a reliable and quick way to test for red-green colour blindness (Ishihara, 1972). The full test consists of 34 dotted, coloured plates and the shortened version consists of 24 plates. Each plate shows either a number or shape that cannot be seen by individuals who display symptoms of colour-blindness. The number or shape is unidentifiable by those who suffer from colour-blindness because they are not able to differentiate from the dots surrounding the number or shape from the actual number or shape. No further analysis or analysis was conducted for the results of the Ishihara colour-blindness test because all participants responded correctly to all plates, thereby giving indication of no colour-blindness.

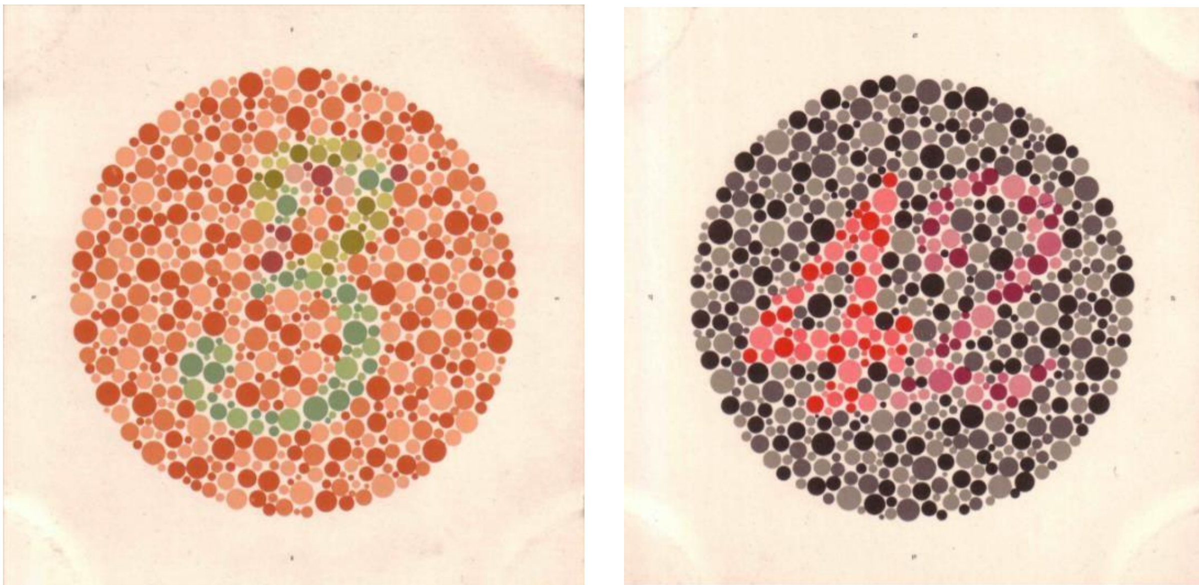


Figure 4. Two example plates from the Ishihara colour-blindness test. Taken from "Ishihara tests for colour-blindness". S. Ishihara. 1972. Tokyo: Kanehara & Co

3.5.3 The Stroop Task

The Stroop task has been used to measure cognitive processing where participants are presented with various words and asked to identify the colour of each word (Stroop, 1935). According to Goldstein (2011), the difficulty and intensity of task irrelevant stimuli makes it difficult for an individual to ignore. As discussed in section 2.3, this creates conflict in the cognitive system between what is relevant and irrelevant which has an impact on cognitive load and the allocation of resources to the task at hand (Kelley & Lavie, 2011). This characteristic represents an important function of decision making and is commonly tested using the Stroop task. The Stroop effect was discovered by John Ridley Stroop (1935) and showed the occurrence of cognitive interference in an individual when exposed to two or more demanding stimuli. The Stroop task has since become a widely used task in studying selective attention and, later on, the cognitive processes associated with it (Gul & Humphreys, 2015; Lamers, Roelofs & Rabeling-Keus, 2010; Macleod, 1991, 1998).

In the classic version of the Stroop task, participants are required to name the colour of the ink in which a word is written while ignoring the meaning of the word. For example the word "red" may be written in the colour red (Lamers et al., 2010). This congruent example is relatively easy and participants respond quickly. There are incongruent examples, however, where the word "red" may be written in green ink. Figure 5 shows an example of the classic Stroop task with congruent and incongruent stimuli.

Figure 5. Classic Stroop task with congruent and incongruent stimuli.

The interference of irrelevant task stimuli during the Stroop task demands more attention and cognitive resources resulting in slower response times (Gul & Humphreys, 2015). The ability to ignore irrelevant stimuli and focus on the task at hand is important when it comes to making a decision (Orquin & Loose, 2013). For this reason, a participant's response time on the Stroop task may be used to determine whether cognitive load and emotionally arousing words have an impact on their decision making, with faster response times indicating easier, more effective decision-making (Orquin & Loose, 2013; Van Merriënboer & Sweller, 2005).

Recently, a computerised version of the Stroop task has become popular instead of the paper-based version (DiBonaventura, Erblich, Sloan & Bovbjerg, 2010). The benefit of this is that response times are recorded more accurately as they are done electronically rather than by the researcher or research team manually. Numerous studies have therefore switched to using a computerised version (DiBonaventura et al., 2010; Parsons, Courtney & Dawson, 2013; Penner et al., 2012).

A computerised version of the Stroop task was used in the current study to test an individual's decision making while cognitive load and emotional arousal are being manipulated. Since the introduction of the original Stroop task (Stroop, 1935), numerous variations have been developed (Macleod, 1991). The variations include using visual stimuli instead of auditory stimuli (using pictures instead of words), having participants complete the Stroop task on more than occasion over an extended period and sorting and matching stimuli (Macleod, 1991). Each variation has its own credible benefits. Following an in-depth review, Macleod (1991) found that using the original name task in a single study is most effective. In the current study, the experiment was presented on a laptop computer using the Sensomotoric Instrument (SMI) Experiment Center™ software suite which is a software package that accompanies the eye tracker which is used as a pupilometric measure of cognitive load and emotional arousal (Ooms et al., 2014). Experiment Center™ is a computer program that allows for the design of an experiment using various stimuli (text, video simulations and websites) as well as the opportunity to build in a questionnaire (Dobešová & Malcík, 2015; Ooms et al., 2015). Figure 6 shows a screen capture of the user interface of the Stroop task created in Experiment Center™.

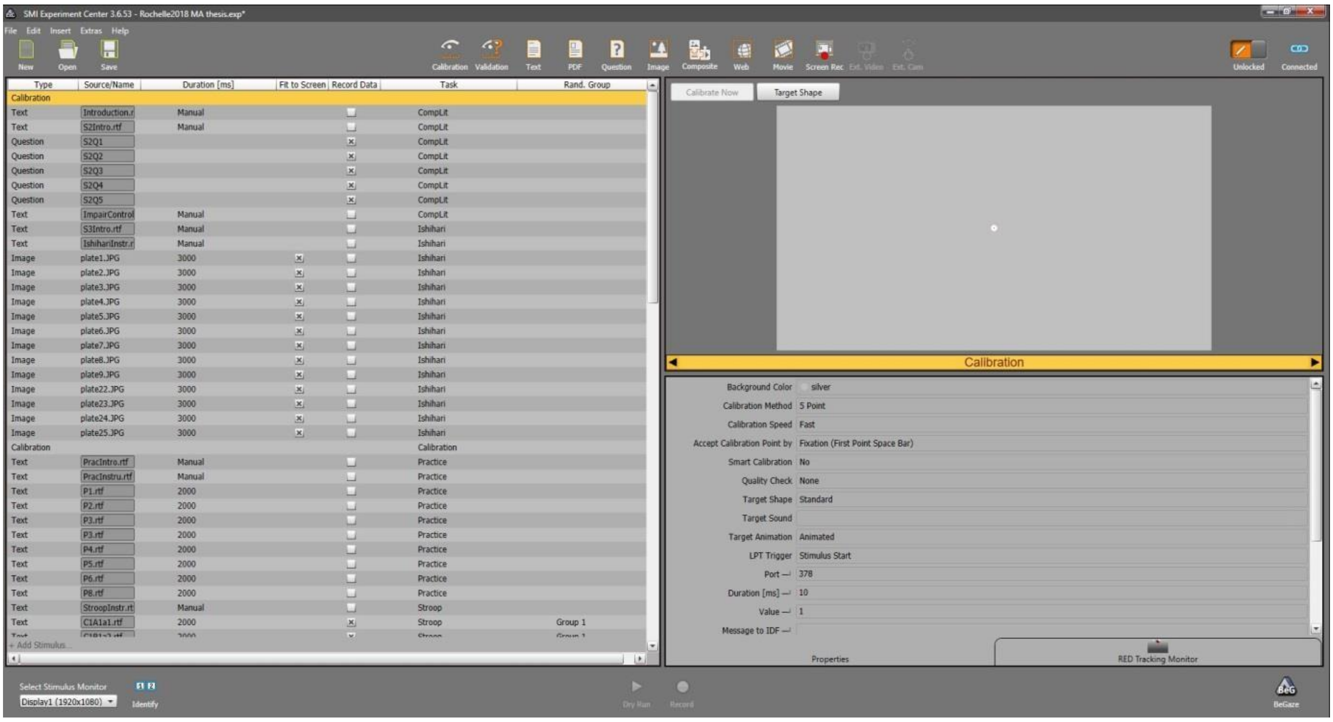


Figure 6. Experiment Center™'s user interface used to create and display the Stroop task

A modification of the classic Stroop task, the emotional Stroop task, includes emotional words instead of colour words (Gotlib & McCann, 1984; Williams, Mathews & Macleod, 1996). For example, the word "hate" may be presented instead of the word "red". It is required to read or press the corresponding colour button but the emotional meaning of the word, as in the incongruent condition, interferes with this process, causing a delayed response.

This study uses elements of both the classic and emotional Stroop task. The classic Stroop is used where congruent and incongruent words are viewed as low load and high load words respectively. Emotionally arousing words of different intensities are also included in the study.

The types of words that were used were (see Appendix A for an extensive list of emotional word stimuli, taken from Eilola and Havelka, 2010):

Low emotional words (A). Words that are commonly viewed as nouns (tree, cloud, pillow). These words will also include colour names (red, yellow, green, etc.) as they appear in the Classical Stroop Task.

Mild emotional words (B). Words that elicit either positive or negative emotions (warmth, loneliness, joy).

High emotional words (C). Words that are viewed as inappropriate and socially prescribed profanities (wanker, slut, whore).

All types of words will be presented in two conditions, namely the emotional arousal condition (condition 1), the load condition (condition 2).

Condition 1. Words presented on the screen include both colour words (red, yellow, green, etc.) as well as varied emotional intensity words (neutral, emotional and taboo words) and are labelled A1, B1 and C1. This condition seeks to measure emotional arousal only. These words will be presented in black font only.

Condition 2. Words presented in this condition include both colour words (red, yellow, green, etc.) as well as varied emotional intensity words (neutral, mild and strong emotional words). Instead of the colour words being presented in the same ink colour (e.g. RED will be presented in red ink), they will appear in different ink colours. For example, the word RED will appear on the screen in blue ink. The order of the presentation of colours will be random. The emotionally arousing words, regardless of intensity, will also be presented in colour. This condition seeks to measure both emotional arousal and cognitive load (labelled A2, B2 and C2). Therefore, condition two is the high load condition manipulated by incongruent colour words and colour emotional words.

Participants will be presented with words of three different emotional intensities (A-C as above) for all the conditions across the screen individually. The words, regardless of condition, will be in upper case with a font size of 72 against a grey background. Participants will be instructed to read the screen and after every word identify the colour of the ink of that word. It has to be selected by pressing the corresponding colour key on the keyboard (the “S” key is covered with a red sticker, “D” with a green sticker, “F” with a blue sticker and “G” with a black sticker). Reaction time, the time of being exposed to the word until the time a colour-key is pressed, is indicative of the time it takes to make a decision and react. Important to note is that reaction time is viewed as decision time plus movement time of the participants. It is therefore the best proxy for decision time.

Referring back to Table 1, there were 10 items presented per condition. Each item was presented for two seconds and the eye tracker (as discussed below) records 60 data points per second, making it a total of 120 data points per a single trial. Considering that the sample size was 12, 86400 data points were recorded in total as there are 120 data points for every 60 items (120 data points per items x 60 items x 12 participants). Data points are read as recording of pupil diameter. There were a total of 720 reaction time observations and measures of correctness during the Stroop task (12 participants x 60 items).

3.5.4 Eye tracker

The screen-based SensoMotoric Instrument (SMI) Eye Tracker was used as a physiological measure of cognitive load and emotional arousal. The SMI RED250 model was used with a sampling rate of 60 hertz (Hz). This means that the eye tracker used can record 60 frames per second. Together with Experiment Center™ and BeGaze™ software suites, the data recorded by the eye tracker will be used to obtain a pupilometric measure of cognitive load and emotional arousal. Individuals are required to respond to the task presented on the screen during the experiment. The remote Eye Tracker was mounted onto the laptop on which the participant was working and has not been found to be an invasive instrument. The eye tracker was calibrated before every participant started the Stroop task using Experiment Center™. The eye tracker recorded data obtained from both eyes and could also be calibrated with individuals who have glasses or were wearing contact lenses. No issues were experienced during the calibration phase of the experiment.

The entire experiment was presented on the computer screen in front of the participant where all responses are recorded. Outputs are recorded in various forms such as heat maps, bee swarms and gaze plots. Pupil dilation, as a measure of cognitive load and emotional arousal, is the output that was of concern and was solely focussed on. The eye tracker was administered according to the manufacturer’s manual. All participants completed the same task. Also, to limit the influence of results due to the environment, the same venue with the same lighting and ventilation was used for all participants. The entire setup of the laptop, colour keys and the mounted eye tracker can be seen in Figure 7 below.

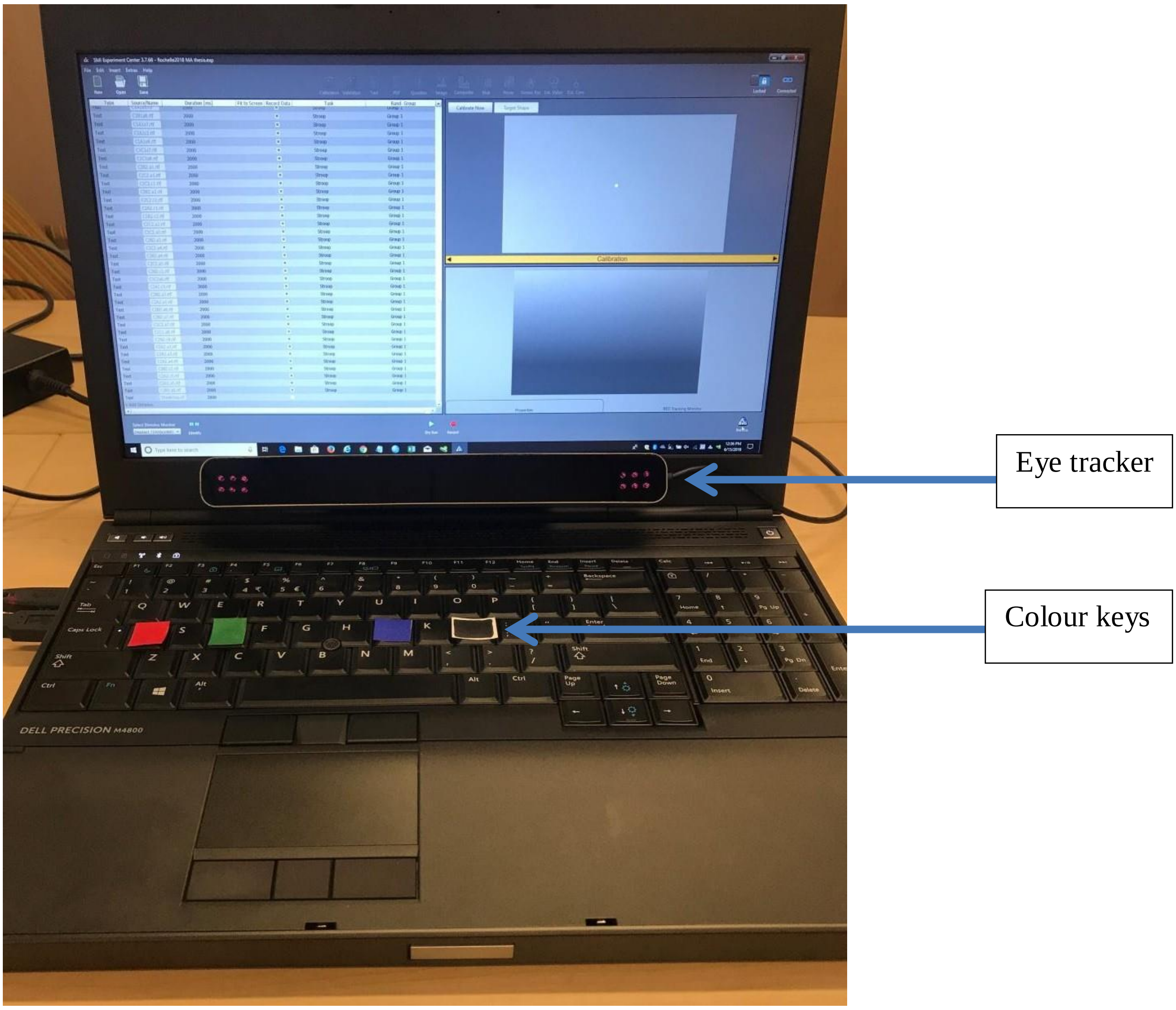


Figure 7. Experiment Center™'s user interface used to create and display the Stroop task.

3.5.5 Recruitment and pre-experimental tasks

Participants were invited to participate in the research study via ClickUP (Appendix B). The sample population, as described in 3.4.3, was then able to view the announcement on ClickUP. The announcement contained a brief explanation of the study as well as the researcher's contact details. Those willing to participate contacted the researcher who set up a suitable date and time for both parties via email for the experiment.

The experiment took place in an empty office in the University of Pretoria Psychology Department. The blinds in the room were drawn and the light was turned on to make sure that all data collection sessions occurred under the same lighting conditions. The reason is firstly for standardisation purposes and secondly, light entering the eye can cause pupil dilation which could act as a confounding variable. By controlling the lighting conditions, the researcher aimed to reduce the influence of light other than that form the screen on collecting data. Participants were seated at a desk with the laptop and eye tracker already fitted into place. The researcher was seated approximately one metre to the left of the participant and remained there throughout the experiment.

Upon arrival, participants were welcomed and once seated were given the information sheet and informed consent form (Appendix C). Once they felt that they were familiar with the purpose, potential risks and benefits related to participating, they were encouraged to ask any questions they may have. Even though it is in the information and informed consent form, the researcher reiterated that the participants would be exposed to explicit words, like swear words. Following this, the participants were asked to sign the informed consent if they were willing to participate. If they were not willing, they were thanked for their interest and asked to leave with no negative consequence.

After signing the informed consent form, the participant was asked to focus on the laptop screen so that calibration could commence. The proceedings of the experiment was explained to each participant where the researcher reminded them that if at any point they did not want to continue, they were allowed to stop the experiment and would be allowed to leave without any kind of punishment or discrimination. The participant then started the experiment.

3.5.6 Experimental task

Each participant was assigned a participant ID to make sure that their participat ion and responses remained confidential.

3.6 Data collection procedure

3.6.2.1 Computerised survey

The participant was told that before they could begin with the actual task, they would be required to complete a survey which collected demographical information and made sure that they do not have any conditions that could be triggered by the experiment. The survey also ensured that all participants had basic computer literacy. The survey was completed electronically. All verbal instructions given to participants were exactly the same as they were read off a script (Appendix D).

3.6.2.2 Ishihara colour-blindness test

After the survey the necessity of testing for colour-blindness, as discussed in section 3.5.2, was explained to the participants. Each participant was required to identify the number within each plate to be able to continue with the experiment. The screen was positioned 75cm from the participant as per the Ishihara Test Manual’s instructions and the participants had 3000ms per plate to identify the number (Ishihara, 1972). A total of 13 plates were presented meaning that it took each participant 39 seconds to complete the test.

3.6.2.3 The Stroop Task

Upon successful completion of the Ishihara colour-blindness test, participants were instructed that the experiment consisted of two parts. The first part would be a practice session where participants would be exposed to a number of strings of meaningless words (e.g. XCDFER) in both colourful and black ink and would be required to press the corresponding key. The reason for this is to ensure that all participants feel at ease about the task and become familiar with the colour keys on the keyboard, reducing the risk of slow response time due to unfamiliarity with instructions. The second part would be the actual task and would be much longer than the first.

The responses for the second part of the study will be recorded. A second calibration was done with the eye tracker right before the start of the practice trial to ensure the recording of pupilometric data. Following calibration and the practice session a final set of instructions appeared on the screen, reminding participants to press “A” for red, “D” for green, “J” for blue and “L” for black. These keys had coloured stickers on them and were required to be pressed in order to complete the task. The colour coding was done to ensure that participants could easily press the right colour key instead of relying on their ability to recall information, reducing the risk of memory acting as a confounding variable during the task. Using a colour coding system during the computerized Stroop task is a strategy used by many authors (Afsaneh et al., 2012; Shichel & Tzelgova, 2017).

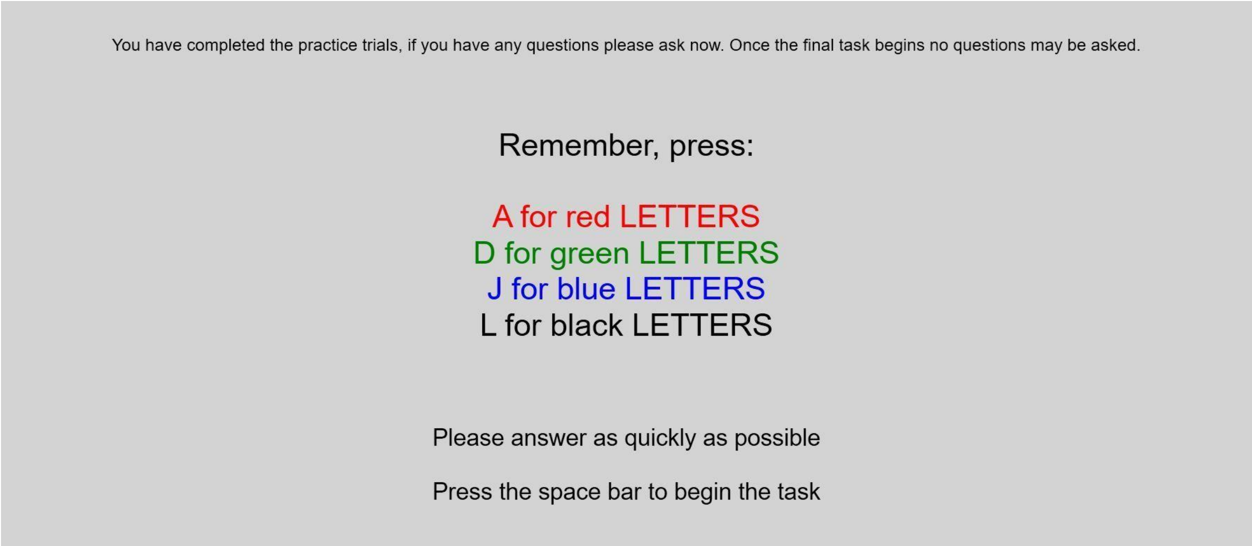


Figure 8. List of instructions presented to participants before the practice session.

Once participants had read the instructions and were ready, they pressed the space bar to begin the practice session. The practice session consisted of 8 practice trials. Once complete, a final set of instructions appeared on the screen informing the participants that the actual task would begin. Any final questions asked by the participants were answered by the researcher and then the researcher moved away from the participant, ensuring the participant that they are present if there are any technical problems. The data collection phase of the experiment consisted of 60 trials, which were presented sequentially every 2000 ms.

The order of the words presented was the same for every participant and was in random order regarding level of load and intensity of arousal. Each participant was therefore required to complete a total of 72 trials. Macleod (1991) suggests that the total number of trials in a Stroop task should be over 50 to allow participants to become familiar with the task. The task took an average of three minutes to complete because the presentation of every trial was set to every 2000ms. A debriefing session, as discussed in section 3.9.4 of this chapter, followed the completion of the task where the researcher clarified any questions the participant might have and, if needed, referred them to an available psychologist for support if need be. No participants felt the need to be referred. The researcher thanked the participant for their time and participation, ending the experiment.

3.7 Validity and Reliability

The foundation for empirically sound research is using measurement instruments that have good psychometric properties (DeVon et al., 2007). Confirming the reliability and validity of measurements instruments used in this study ensures the integrity of its findings.

3.7.1 Stroop task

In view of the Stroop task being created in 1935, there have been numerous studies on its validity and reliability. The Stroop task has been found to be highly reliable with test-retest coefficients for the task ranging between .71 - .88 (Fernández-Marcos, De La Fuente & Santacreu, 2017; Strauss, Allen, Jorgensen & Cramer, 2005). Numerous other studies have found the Stroop task to be high in reliability across a variety of situations (Gwizdka, 2010; Santos & Montgomery, 1962; Schubo & Hentschel, 1977, 1978; Smith & Nyman, 1974; Uechi, 1972). It is important to note that the reliability of the Stroop task is highest when reaction times, or speed measures, were used (DeVon et al., 2007).

As a result of its different versions, determining the Stroop task's validity is more complicated than its reliability (Macleod, 1991). However, interference effects (as seen in the classic Stroop task) can also be observed in most of the other versions of the Stroop task (Macleod, 1991). This means that even though specific versions of the Stroop task are used to test for specific constructs- for example, the Emotional Stroop is used to test one's emotional state- the struggle between colour naming and word spelling is still present. Regardless of data collection methods, the way in which the task is completed or how the participants are instructed to complete the task, multiple studies found still found the existence of that interference effect (McCown & Arnoult, 1981; Peretti, 1971; Regan, 1978; Zajano, Hoyceanyls, & Ouellette, 1981). The Stroop task, therefore, is highly valid across different contexts (Macleod, 1991).

3.7.2 Eye tracker

Using an eye tracker to measure pupil dilation (PD) has been found to be highly reliable. Studies have found the Cronbach's alpha (α) of eye tracking technology and PD to range between 0.995-0.997 which is well above what is considered ideal (α = 0.7) (Murray, Hunfalvay & Bolte, 2017). Multiple studies agree with this finding but stated that reliability may decrease due to incorrect positioning of the participant in front of the eye tracker (Holland & Siderov, 1998; Jiang & Ramamirtham, 2005; Obstfeld & Chou, 1998). It is for this reason that calibration is necessary and that the positioning of the eye tracker is not altered between participants (Murray et al., 2017; Jiang & Ramamirtham, 2005). It is also important to make sure that participants' eyes are fixated on the screen throughout the experiment and that they are positioned 60 to 80 centimetres from the screen. This ensures for more accurate results (Kooiker et al., 2016). Regardless of what kind of eye tracking technology was used or the kind of stimuli that was presented on screen, multiple studies have found that eye trackers accurately measure pupil dilation (Kooiker et al., 2016; Murray et al., 2016; Obstfeld & Chou, 1998; Wachler & Krueger, 1999).

3.7.3 Statistical Conclusion Validity

Statistical conclusion validity (SCV) needs to be discussed because statistical tests play a big role in quantitative research designs (Levine, 2011). SCV refers to the ability of a measurement tool to make an accurate assessment about whether the independent and dependent variable are related and about the strength of that relationship (García-Pérez, 2012; Shadish et al., 2002). In order to uphold SCV, Cook and Campbell (1979) stated that in order for these assessments to be accurate, they have to be true. There are numerous threats to SVC, including unreliability of measures, violated assumptions of test statistics, low statistical power and extraneous variance in the experimental setting (Shadish et al., 2002). When a measure is deemed unreliable, its integrity is questioned (Maxwell & Delaney, 1990). As was discussed in section 3.7, both the Stroop task in various contexts as well as the eye tracker is considered highly reliable (Macleod, 1991; Murray et al., 2017), suggesting that this study's SCV was not influenced by unreliable measurement instruments. The statistical measures used in the study did not violate any assumptions, as shown in chapter four. It is acceptable to then assume that the study's SCV was not influenced by violated test assumptions. When it comes to low statistical power, the power of a test refers to its ability to detect relationships between variables (Maxwell & Delaney, 1990). One of the main factors that affect the power of a test is sample size (Shadish et al., 2002). This factor may have threated the SCV of this study considering the small sample size (n=12). Lastly, extraneous variables will inevitably impact the study in some way as it is nearly impossible to completely control the entire experimental setting (Shadish et al., 2002). There is therefore a possibility that variables outside of the experiment (for example, distracting noise) may have impacted the performance of participants and impacted the study. In attempt to reduce extraneous variance, standardised procedures (section 3.6) were followed during the data collection process.

3.8 Data analysis

This section discusses the quantitative analysis procedures used in this study. Data analysis is a very important part of the research process and precedes interpretation. To determine whether cognitive load and emotional arousal had an impact on decision making, a repeated measures factorial analysis of variance (ANOVA) was conducted using version 25 of SPSS (IBM Corp, 2016). This technique allows the researcher to look for main and interaction effects of the independent variables on the dependent variable (Pallant, 2013; Tabachnick & Fidell, 2013). The independent variables in this study were cognitive load and emotional arousal and the dependent variable was decision making (operationalised as pupil diameter). An advantage of using a repeated measures design is that the main effect for each independent variable can be tested and the possibility of an interaction effect can also be investigated (Pallant, 2013). An interaction effect occurs when an independent variable's impact on the dependent variable is affected by another independent variable (Tabachnick & Fidell, 2013). For example, in this study, it may be found that the influence of cognitive load on decision making is different for low or high states of emotional arousal. The results of this analysis are presented in chapter five. The cognitive load and emotional arousal of participants were determined from their pupil diameter during the computerised Stroop task. Participants' decision making was determined from their response time on the computerised Stroop task. A more detailed discussion of the data analysis follows under two main sections. The first section discusses the analysis and presentation of the pupil diameter results and the second section discusses how the data was analysed using SPSS and a repeated measures factorial ANOVA.

3.8.1. Presentation of pupil diameter results

Data was exported to excel, adjusted and then imported in R as a data frame. R version 3.5.0 (2018) was used because of its ability to manage long data frame format and plotting capabilities. The data required for the factorial ANOVA was extracted by R, converted to a wide data format and imported in SPSS (see below). Observations such as marker information were removed and all eye blinks were converted to fixations. These fixations were set to missing data. Missing data for one eye was replaced by data from the other eye when available. Right and left eye diameter was then averaged with missing values for data where data for both eyes were missing. These missing values were imputed by an R algorithm (Engelhardt, Ferreira & Patsenko, 2018)

Using ggplot2 procedure (Wickham, 2016), various plots were constructed to enable a visual representation of pupil diameter across 2000 ms for each presentation. Data for load and arousal were aggregated and separately depicted. Data for low load and high load across arousal were also aggregated and plotted. In each instance the raw data was plotted, then in order to do comparisons between the various conditions, each condition was set to a baseline of zero percentage dilution by subtracting the average of the first time slot (16 ms) from each observation and then dividing by this average (Lemercier et al., 2014; Tromp, Hagoort &

Meyer, 2018). This transformation yielded a percentage of dilution and allowed graphs to start at the same baseline in order to visualise real differences between conditions and their levels.

Each plot, namely, the raw plot for actual pupil dilation (mm) and the "standardised" plot namely percentage of dilation was presented in original and smoothed plots. The smoothed plot used the auto method (based on sample size) to smooth data points and enable inspection and data analysis (Wickham, 2016).

The next step was to compare pupil diameter in two segments, namely the lowest point of each graphs inflection and the highest point. The lowest point can be regarded as the baseline point of each exposure's pupil dilation and the highest point included the segment where the pupil responded optimally to the visual stimulus. Segments were between 417 ms-734 ms and between 1167 ms-1417 ms. These segments were averaged to obtain single values per condition for each participant and then analysed by SPSS as discussed below (Tromp et al., 2018).

3.8.2 Repeated measures factorial ANOVA

As indicated in section 3.5.3 above, the eye tracker results resulted in more than 86400 observations or data points aggregated across 12 subjects. The results were exported from the SMI system in a time series or long data format. The raw data consisted of some gaps where the pupil diameter could not be estimated (such as when a participant looks at the key board or blinks) (Engelhardt et al., 2018). In addition the eye tracker recorded pupil diameter for both eyes and these results can be used to infer missing values (Lemercier et al., 2014). Information such as key presses, reaction time and various markers were incorporated in the data set which means that a data cleaning process had to be done followed by a process of imputing missing values in order to ensure a continuous data set (Holmqvist, 2012). Of course, large segments of missing data would render observations not useable thus the data was checked for large sections of missing data. Normally one would discard records if missing values more than 25 % of the unit were found (Tromp et al., 2018). An observation unit in this case was observations on a trial per person (of which there were 60).

Following the data cleaning process, the second part of the analysis was conducted in SPSS (IBM Corp, 2016). Alpha levels were set at $\alpha = 0.05$. This means that the null hypothesis will only be rejected if there is at least 95% probability that the rejection of the null is the right decision and not caused by sampling error. This also means, however, that there is a 5% chance of committing a type I error where the null hypothesis is rejected when it is actually true. By conducting repeated measures ANOVA's the probability of committing a type I error can be kept at $\alpha = 0.05$ by combining the error associated with each comparison and therefore comparing each condition at the same time, consequently making up for the probability of committing a type I error during multiple comparisons (Field, 2013).

ANOVAs with repeated measures are prone to the violation of the assumption of sphericity. Sphericity is the condition where the variances of the differences between all combinations of related levels are equal (Field, 2013). Violation of sphericity is therefore when the variances of the differences between all combinations of related groups are not equal. Sphericity applied to conditions that included emotional arousal because, according to Field (2013), three levels of a factor are needed for sphericity to be an issue. If there were less than three levels, sphericity was assumed. To assess sphericity, Mauchly's test was run for all data and the analysis revealed that the assumption of sphericity had not been violated for all conditions ($p > 0.05$).

After having dealt with missing values and the assumption of sphericity had been addressed, as discussed above, data was reorganised and averaged for participant scores (correct/incorrect), reaction times and percentage of pupil dilation for all six experimental conditions as identified in Table 1. The mean responses times and mean scores were then subjected to a 2 x 3 repeated measures ANOVA with emotional arousal (3 levels) and cognitive load (2 levels) as the factors and response time and correctness of scores as the dependent variables respectively. The repeated measures ANOVA was also used to investigate the possible existence of interaction effects between emotional arousal and cognitive load with regards to mean reaction time and correctness of scores.

Pupil dilation percentage deviation was broken up into two time segments (417 ms-734 ms and 1167 ms-1417 ms) for analysis as mentioned above. A 2 x 3 repeated measures ANOVA was run for both time segments with emotional arousal (3 levels) and time segment (2 levels) as the factors and pupil dilation percentage deviation as the dependent variable. In order to investigate the relationship between emotional arousal and cognitive load, a 2 x 3 repeated measures ANOVA was run for emotional arousal (3 levels) and cognitive load (2 levels) as the factors and pupil dilation deviation percentage as the dependent variable for time segment B only, as this was when there was optimal pupil response to the stimulus.

3.9 Ethical considerations

It is important for researchers to consider certain ethical guidelines to protect participants from possible harm (Salkind, 2009). Salkind (2009) explains that it is the researcher's responsibility to ensure the psychological welfare and dignity of those who participate in their research remain untouched throughout the experimental process. Numerous ethical issues are important to consider when conducting research in the social sciences (Willig, 2009). These include avoiding harm, informed consent, confidentiality and debriefing after the end of the experiment (Willig, 2009). These ethical concerns and how they were applied in the study are discussed below. It is important to note that ethical clearance to use emotionally arousing stimuli was granted before the research took place.

3.9.1 Avoiding harm

The data collection phase of the experiment did not include procedures that were potentially harmful or dangerous. Furthermore, the experiment took place in a safe environment at the University of Pretoria. As a result, participants were not put in any immediate danger throughout their participation.

3.9.2 Informed consent

Upon arrival at the experimental venue, participants were provided with an English consent form. They had been informed during the recruitment phase of the study that their participation is completely voluntary and that they would not receive any incentive for participating. Participants were informed, both in written and verbal form, that they had the right to withdraw from the study at any time with no negative consequences. The consent form included a brief explanation of the nature of the study and what equipment would be used and also stated that explicit words were used in the experiment (Appendix C). Before signing the form, the researcher verbally reiterated that explicit words were part of the experiment and should participants feel uncomfortable at any point, they could withdraw immediately. After signing the form, participants were presented with a copy of the information part of the form together with the researcher's details for possible future enquiries.

3.9.3 Confidentiality

The participants were informed, verbally and in the consent form, that all identifying information would be treated as strictly confidential and that only the research team would have access to the results. Participants were also informed that data would be reported on collectively and in cases where the data was reported on an individual level, no personal identification markers would be used. Each participant received a unique identification number that was not connected to their personal identity, other than age, gender and level of education, in any way. Participants were also informed that, as per regulations, all collected data would be securely stored in a digital format in HB 11/24 in the Department of Psychology for 15 years.

3.9.4 Debriefing

Every participant was debriefed after the experiment. Participants were given the opportunity to ask any questions they had related to the experiment and their participation. Debriefing involved a discussion on how the participants felt during their participation and also a brief explanation of why they may have felt frustrated during more difficult trials (high load and high arousal conditions). The researcher also explained how pupils dilate as a result of load and arousal and that was what the eye tracker was measuring. Participants were reminded that the researcher's email address was on the information sheet and that any further concerns could be addressed through email. The researcher was also ready to refer any participants to a qualified counsellor at the University of Pretoria, should they experience any discomfort or anxiety as a result of their participation in this study. None of the participants in this study required counselling as a result of their participation in the research process.

3.10 Chapter summary

The aim of this study was to investigate whether emotional stimuli and cognitive load have an impact on decision making. To explore this aim, an experimental factorial design was utilised where participants were asked to complete a computerised version of the Stroop task to determine their decision making ability by using reaction times. Participants were sampled using non-probability convenience sampling which resulted in a final sample size of 12. Data was collected using the Stroop task. During the Stroop task, an individual is required to respond to the colour of a printed word and ignore the meaning of that word (Lamers et al., 2010). Participants usually perform more poorly in the task when they are confronted with incongruent examples, where the colour of the word and the meaning of the word do not match (Goldstein, 2011). Additionally, response times are usually slower when confronted with highly arousing words compared to neutral words (Orquin & Loose, 2013). This occurs because task-irrelevant stimuli, whether it causes a condition of high load or high arousal, cause a delayed reaction time (Gul & Humphreys, 2015). Therefore, an individual's reaction time in the Stroop task serves as an indicator of the participant's decision making ability under conditions of high load or arousal (Orquin & Loose, 2013). Both the traditional and computerised version of the Stroop task show good levels of validity and reliability across a variety of situations (Fernández-Marcos et al., 2017; Macleod, 1991). To analyse the data obtained in this study, a two-way repeated measures analysis of variance (ANOVA) was used. The advantage of using two-way repeated measures ANOVA is that the researcher is able to test the main effects of each independent variable while also exploring the possibility of an interaction effect. To ensure the safety of participants, numerous ethical guidelines were upheld during the research process including avoiding harm, informed consent, confidentiality and debriefing. The results of the study are described in the following chapter.

CHAPTER 4

RESULTS

4.1 Introduction

In this chapter, the results of the study are presented. This includes the results of a repeated measures factorial ANOVA which tested for main and interaction effects with regard to emotional arousal and cognitive load on an individual's pupil dilation. Results are presented according to participants' responses throughout the experiment as well as pupil dilation as measured by the eye tracker.

4.2 Participant responses

The data collected from participants using the computerised Stroop task is presented in this section. As discussed in section 3.7.1, the Stroop task is considered to be a valid and reliable measure. The results of the correct and incorrect responses are first presented. Secondly, the mean reaction time (RT) scores is presented followed by the results of a repeated measures ANOVA which determined if significant differences exist between levels of emotional arousal, cognitive load and reaction time, while also testing for interaction effects.

4.1.1 Correct/Incorrect responses

4.1.1.1 Mean score results

Participants were required to make decisions during the Stroop task. Their responses were classified as correct (the colour of the word presented on the screen was the same as the colour key selected) or incorrect (the colour of the word presented on the screen was different to the colour key selected). These responses were recorded and classified as 0 being incorrect and 1 being correct. The mean responses for participant scores are presented in Table 3 below. The high load, low arousal condition received the lowest number of correct scores with a mean of 0.24 where the low load, low arousal condition received the most correct scores with a mean of 0.46. By looking at the table, the high load conditions, regardless of level of arousal, all had a mean score 0.33 where all the low load conditions had a mean higher than 0.40 with a range of 0.22.

Table 3: Descriptive statistics for score

Load	Arousal	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Low	Low	0.42	0.07	0.26	0.57
	Mild	0.40	0.06	0.26	0.54
	High	0.46	0.06	0.32	0.59
High	Low	0.24	0.07	0.08	0.40
	Mild	0.33	0.07	0.16	0.49
	High	0.27	0.07	0.11	0.43

To determine if these results reached statistical significance, a repeated measures ANOVA was conducted for scores between different levels of emotional arousal and cognitive load and the results are shown in the section below.

Before an ANOVA could be run, it was necessary to check whether the assumption of sphericity had been met. Sphericity is the condition where the variances of the differences between all combinations of related groups (or conditions) are equal (Field, 2013). Studies that use within-subject factors are especially susceptible to violating this assumption, which is why it needed to be checked to ensure the appropriate statistical tests were used during the ANOVA analysis. Field (2013) states that sphericity can only be calculated for three or more groups or variables. Cognitive load had only two groups (high and low load), therefore no calculation of sphericity is necessary and it is acceptable to assume that the assumption of sphericity has been met. Emotional arousal, however, had three groups (low, mild and high) which is why it was necessary to check whether the assumption of sphericity for emotional arousal had been violated. Mauchley's test revealed that this assumption had not been violated for arousal $\chi^2(2) = 2.171$, $W = .805$, $p = .338$. There was also no significant interaction effect between cognitive load and emotional arousal $\chi^2(2) = .291$, $W = .971$, $p = .864$.

4.1.1.2 Repeated measures ANOVA for scores

Following the selection of the appropriate statistical tests to use regarding the assumption of sphericity, a repeated measures ANOVA for scores (Table 4) was run to test what impact, if any, different levels of emotional arousal and cognitive load has on the scores of the participants. All effects are reported as significant at p □ .05. There was a significant main effect of cognitive load on scores of the participants, $F(1, 11) = 34.370$, $p < .001$. There was no significant main effect of emotional arousal which shows that the scores between the levels of arousal (low, mild and high) were the same in general, $F(2, 22) = .710$, $p = .503$. Lastly, there was also no significant interaction effect between cognitive load and emotional arousal. This indicates that the scores in this condition remained mainly the same throughout the experiment, $F(2, 22) = 1.30$, $p = .282$.

Table 4: Test of within-subjects effects for scores

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Load	0.39	1.00	0.39	4.37	0.00
Error (Load)	0.12	11.00	0.01		
Arousal	0.02	2.00	0.01	0.71	0.50
Error (Arousal)	0.28	22.00	0.01		
Load * Arousal	0.05	2.00	0.02	1.34	.28
Error (Load*Arousal)	0.39	22.00	0.02		

The pattern of scores across cognitive load was similar when low, mild and strong emotionally arousing words were used (Figure 9). This means that participants got more items incorrect during high cognitive load when compared to their scores in low cognitive load. Despite a crossover of conditions in the graph, there was no interaction between them.

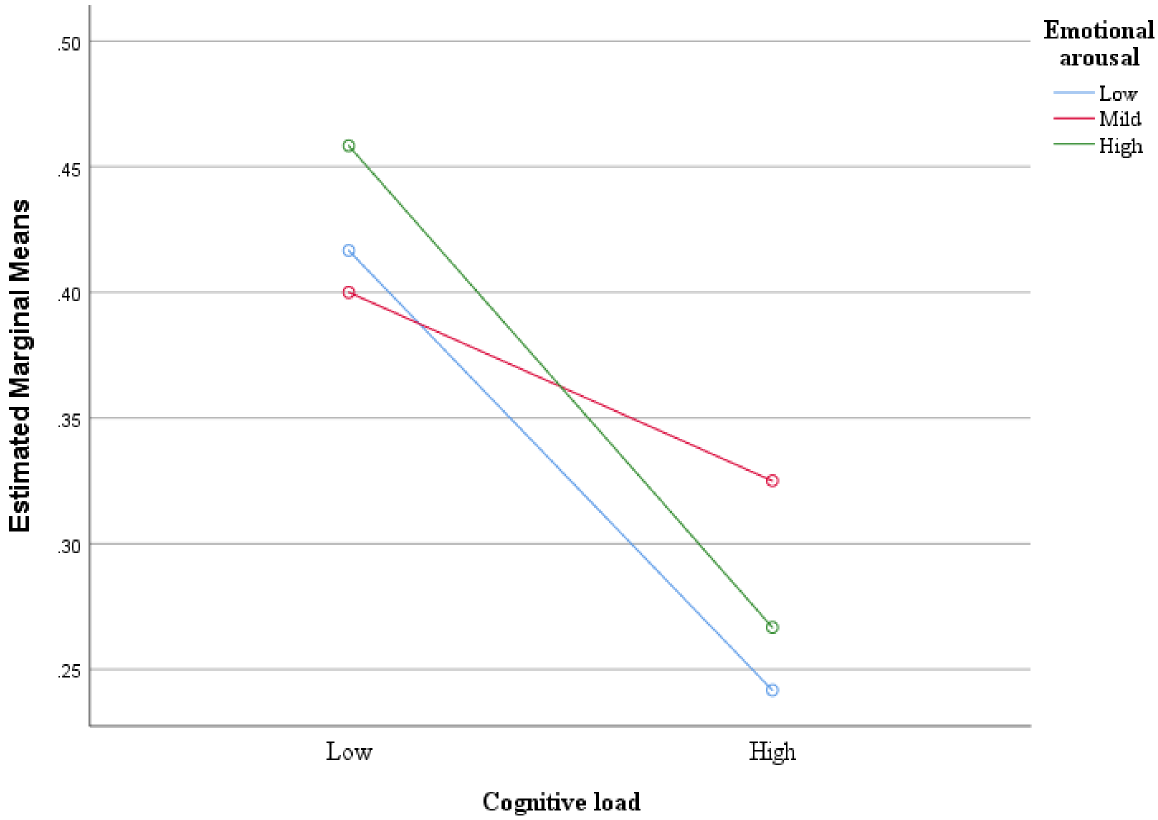


Figure 9. The estimated marginal means of correct responses under different conditions of cognitive load and emotional arousal

4.1.2 Reaction times

4.1.2.1 Mean RT results

Recall that one of the objectives of the study was to measure RT during the Stroop task when exposed to different levels of emotionally arousing words and cognitive loaded stimuli. RT was measured and is reported as milliseconds (ms). The mean response times for all six conditions are presented in Table 6 below. These means are important as they show patterns of means across all experimental conditions. The high load, high arousal mean of 751.69 ms was the lowest mean and the high load, mild arousal had the highest mean of 807.56 ms with a range of 55.87 ms. Despite the small range, the mean reaction time was slowest for the high load, mild arousal condition and fastest for the high load, high arousal condition. The mean of the high load, mild arousal condition could have been influenced by the maximum value for that condition of 1076.48 ms.

Table 6: Descriptive statistics for reaction time (ms)

Load	Arousal	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Low	Low	785.41	38.69	700.26	870.56
	Mild	807.56	39.42	720.80	894.32
	High	751.69	36.25	671.91	831.47
High	Low	795.15	31.80	725.15	865.15
	Mild	784.43	29.79	718.85	850.01
	High	753.35	36.46	673.10	833.59

To determine if these results reached statistical significance, a repeated measures ANOVA was conducted for RTs between various intensities of emotional arousal and cognitive load. The results of this test are shown in the next section.

It was required to check whether the assumption of sphericity had been violated to ensure that the correct statistical tests were used during the ANOVA. As discussed earlier, sphericity was assumed for cognitive load because it contained less than three variables, Mauchly's sphericity test found that the assumption of sphericity had not been violated for the interaction between load and arousal $\chi^2(2) = 4.085$, $W = .665$, $p = .130$ and for arousal $\chi^2(2) = 3.774$, $W = .686$, $p = .152$.

4.1.2.2 Repeated measures ANOVA for RT

Once the issue of sphericity was addressed and the appropriate statistical tests were selected, a repeated measures ANOVA (Table 7) was conducted to explore the impact of emotional arousal and cognitive load on RT during the Stroop task. All effects are reported as significant at p □ .05. There was a significant main effect of emotional arousal on RT, $F(2, 22) = 6.065$, $p = .01$. There was no significant effect of cognitive load, indicating that RTs between low load and high load conditions were the same in general, $F(2, 22) = .063$, p = .81. There was also no significant interaction effect of cognitive load and emotional arousal, indicating that the RTs between the simultaneous combination of load and arousal generally remained the same, $F(2, 22) = .426$, $p = .66$.

Table 7: Test of within-subjects effects for RT

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Load	275.52	1.00	275.52	.06	.81
Error (Load)	47813.17	11.00	4346.65		
Arousal	26788.05	2.00	13394.02	.06	.01
Error (Arousal)	48585.74	22.00	2208.44		
Load * Arousal	3519.81	2.00	1759.91	.43	.66
Error (Load*Arousal)	90965.01	22.00	4134.77		

A pairwise comparison was run (Table 8) using a Bonferroni adjustment where the main effect of arousal had marginal means of 790.28 ms for low emotional arousal, 796 ms for mild emotional arousal and 752.52 ms for high emotional arousal. Table 8 shows that the significant main effect of arousal reflects significant differences between mild and strong levels of arousal ($p < .001$).

Table 8: Pairwise comparisons for emotional arousal

Level of Arousal		Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
				Lower Bound	Upper Bound
Low	Mild	16.25	1.00	-51.55	40.12
	Strong	14.15	.06	-2.15	77.68
Mild	Low	16.25	1.00	-40.12	51.55
	Strong	9.36	.00	17.07	69.88
Strong	Low	14.15	.06	-77.67	2.15
	Mild	9.36	.00	-69.88	-17.07

Based on estimated marginal means

b. Adjustment for multiple comparisons: Bonferroni

The graph below (Figure 10) shows that the pattern of RT across cognitive load was similar when low and high emotionally arousing words were used. That is, RT got slower as cognitive load increased. RT for mild arousing words was different where participants took longer to respond under low load conditions compared to high load conditions.

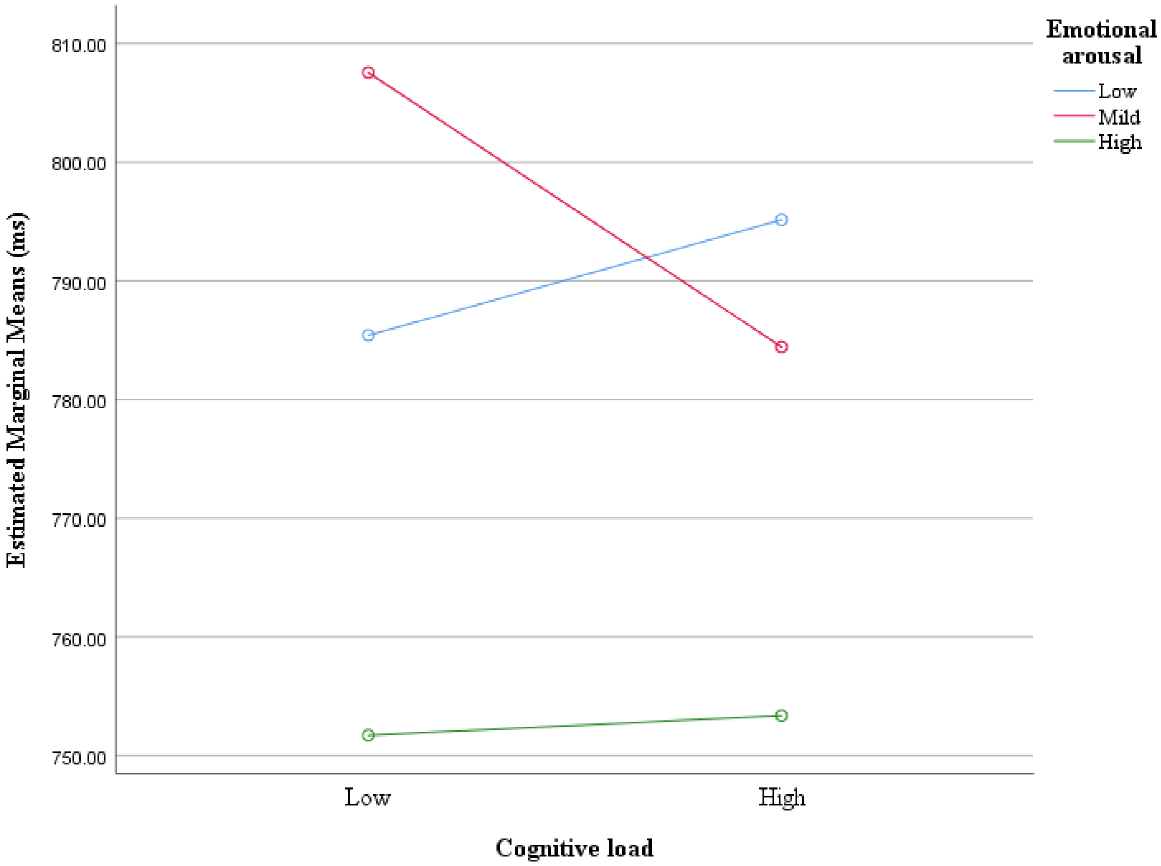


Figure 10. The estimated marginal means of RT under different conditions of cognitive load and emotional arousal.

4.3 Pupil dilation

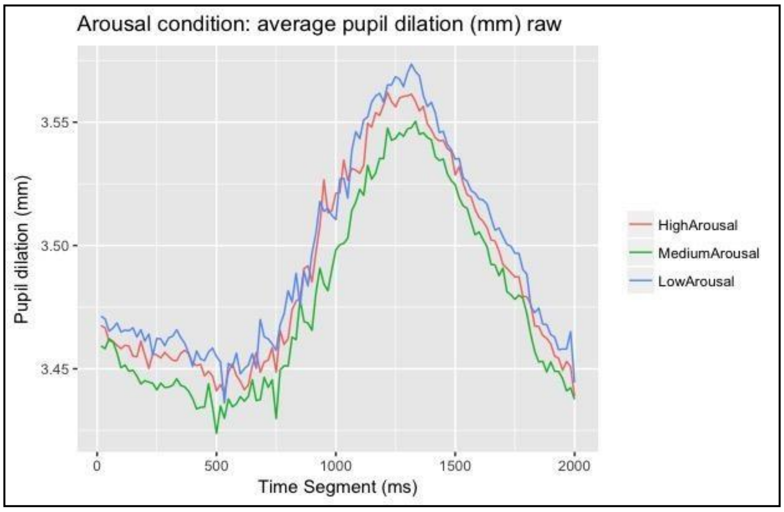
As stated in section 3.5.4, pupil dilation (PD) was measured in millimetres using an eye tracker. The section will begin with a graphic representation of the relationship between PD and time in milliseconds (ms), in the arousal (low, mild, high) and load (low, high) condition. This will be followed with the results of the repeated measures ANOVA for PD which determined if significant differences of varied levels of emotional arousal and cognitive load exist for PD and time (ms).

4.3.1 Pupil dilation and time (ms)

All graphs are presented in their original or raw format first followed by a smoothed version of the same graph. The smoothing process allows for easier interpretation. The time segments for the graphs are also from 0 ms to 2000 ms. The reason for this is that a new stimulus, or word, was shown every 2000 ms (section 3.6).

4.3.1.1 Emotional arousal

The graph below (Figure 11) shows that the average pupil dilation for arousal on all three levels was the lowest just before 500 ms and the highest at about 1250 ms. This means that participants' pupils constricted and dilated at similar time segments. Low and high arousal, however, are much closer with regards to PD than medium arousal during these times.



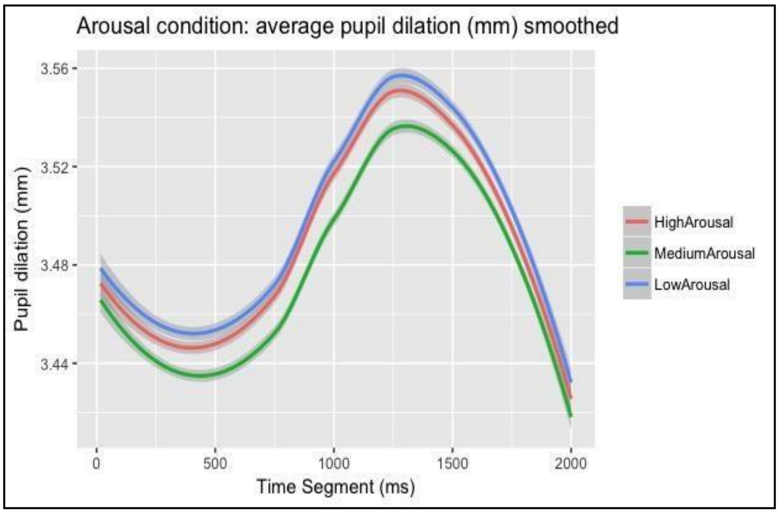


Figure 11. The average pupil dilation (mm) of the raw scores during the arousal condition.

Following the raw score graphs above, a graph of the average percentage (%) of PD is depicted below (Figure 12). Even though the raw scores give an indication of PD, by using % of deviation, a more standardised measure is utilised. Also, raw scores can be misleading because they do not start from a baseline score. As can be seen in figure 12, a baseline score of 0.00 deviation has been established. Note that in the smoothed graph, the baseline score is just above 0 which is a result of the smoothing process.

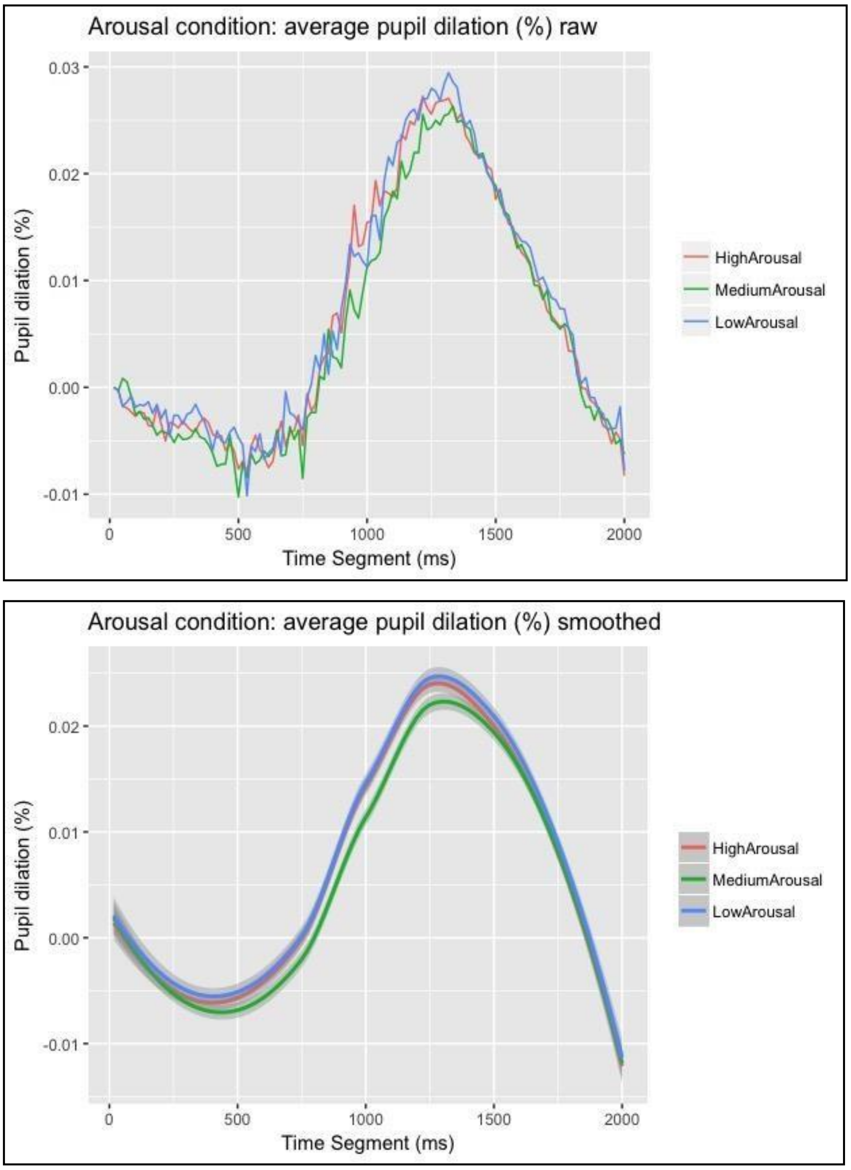


Figure 12. The average pupil dilation deviation (%) during the arousal condition.

The pattern of the average % deviation of PD, irrespective of level of arousal, all begins at the same baseline. Even though mild arousal still shows less PD, the % difference between mild arousal and low and high arousal is considerably less than the difference shown in Figure 11. Even though high and low arousal is very similar, there is no overlap between low and high arousal at the constricted and dilating time segments.

4.3.1.2 Cognitive load

PD in mm for cognitive load over a time frame of 2000 ms is presented in Figure 13 below.

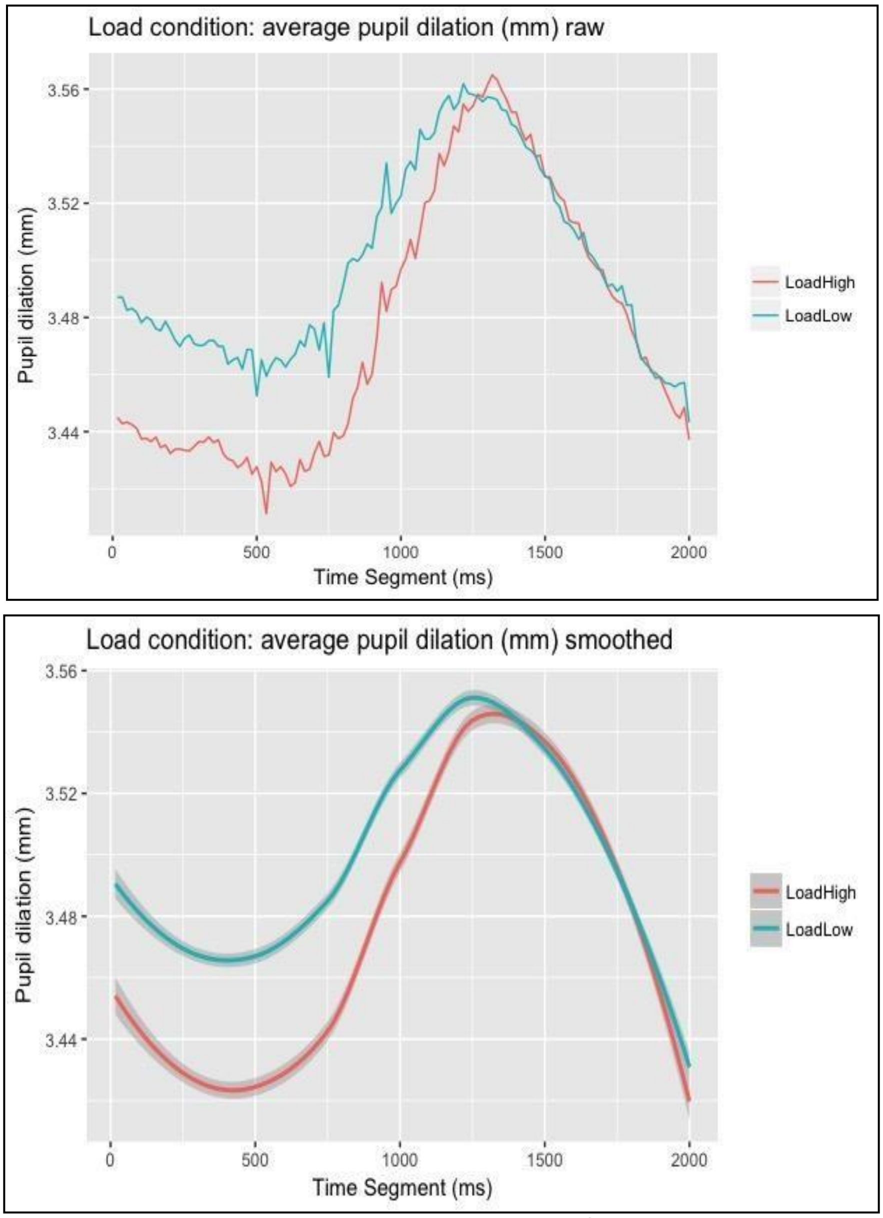


Figure 13. The average pupil dilation (mm) of the raw scores during the load condition.

From the smoothed graph it can be seen that, as with arousal, maximum constriction and dilation of the pupils of participants occurred in a similar pattern with constriction happening just before 500 ms. The raw scores of load show that average maximum dilation for low load happened at about 1250 ms and at about 1350 ms for high load. This means that the raw scores that maximum dilation occurred sooner for low cognitive load than for high cognitive load. Using raw results, as was discussed in section 4.2.1.1, can be misleading which is why using standardised % scores are preferred and utilised in this report.

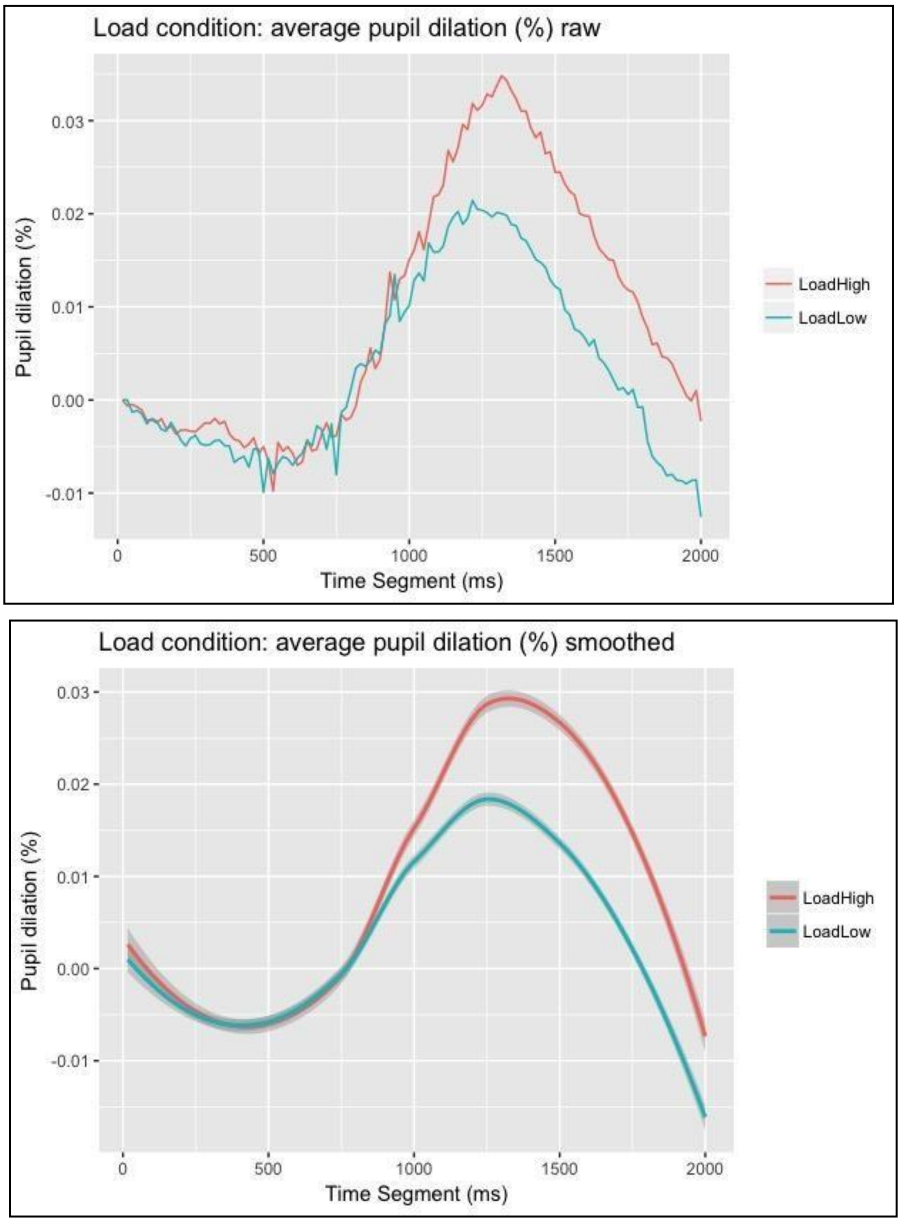


Figure 14 .The average pupil dilation deviation (%) during the load condition

By establishing a baseline of 0.00%, the value of using % over raw scores and PD in mm can be seen when comparing Figures 13 and 14. The smoothed graph in Figure 14 shows that there is little % deviation during maximum pupil constriction, with low and high load almost overlapping just before 500 ms. There is a big difference during maximum average dilation however where the average maximum PD for high load is 0.03% and for low load is just below 0.02%. This means that maximum average PD during the high load condition was more than that of the low load condition.

4.3.2 Repeated measures ANOVA for PD and time (ms)

From the graphs above, two time segments were extracted and compared in the ANOVA for the PD of both arousal and load during the presentation of a stimulus. The segments are indicated by the time (in milliseconds) of each stimulus exposure. The first segment (segment A) was between 417 ms and 734 ms (prior to a response being made by the participant) and the second segment (segment B) between 1167 ms and 1417 ms (post stimulus response). By referring to Figures 12 and 14, the maximum and minimum average PD for arousal and load occurred between these two time segments, which is why they were created.

It was required to check whether the assumption of sphericity had been violated to ensure that the correct statistical tests were used during the ANOVA. Mauchly's sphericity test found that the assumption of sphericity had not been violated for the interaction between arousal and time $\chi^2(2) = 1.13$, $W = .89$, $p = .57$ and for arousal $\chi^2(2) = 2.28$, $W = .80$, $p = .32$. Sphericity is assumed for time and load since Mauchly's W is not calculated for two levels of a variable in both the load and arousal condition, as well as for load and time in the load condition.

4.3.2.1 ANOVA of arousal and time

Table 9 shows the average PD for all three levels of emotional arousal. The mean is reported as % deviation. Low arousal for segment B has the highest mean of 0.027% deviation where segment A for low and high arousal has a mean of -0.005%.

Table 9: Descriptive statistics for arousal and time (segments)

Arousal and time segment		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Low	Segment A	-0.005	0.043	-0.099	0.090
	Segment B	0.027	0.042	-0.065	0.119
Mild	Segment A	-0.006	0.043	-0.101	0.090
	Segment B	0.024	0.042	-0.067	0.116
High	Segment A	-0.005	0.044	-0.102	0.091
	Segment B	0.026	0.042	-0.068	0.119

The repeated measures ANOVA for arousal and time explored the influence of arousal and time on PD during the Stroop task (Table 10). Recall that all effects are reported as significant at p □ .05. There was a significant main effect of time on PD, $F(1, 11) = 29.09$, p □ .001, $\eta^2 = 0.73$. There was no significant main effect of emotional arousal, indicating that PD between low, mild and high levels of arousal were generally the same, $F(2, 22) = 0.08$, $p = .93$, $\eta^2 = 0.01$. There was also no interaction effect between emotional arousal and time, indicating that the PD between the simultaneous combination of arousal and time remained similar throughout the experiment, $F(2, 22) = .30$, $p = .75$, $\eta^2 = 0.03$.

Table 10: Test of within-subjects effects for arousal and time (segments)

Arousal and time	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Arousal	0.00	2	0.00	0.08	0.93	0.01
Error (Arousal)	0.01	22	0.00			
Time	0.01	1	0.02	29.09	0.00	0.73
Error (Time)	0.01	11	0.00			
Arousal * Time	0.00	2	0.00	0.30	0.75	0.03
Error (Arousal*Time)	0.00	22	0.00			

The graph below (Figure 15) shows the average PD across emotional arousal intensities was similar across segment A and segment B. This means that PD was greater at segment A than at segment B.

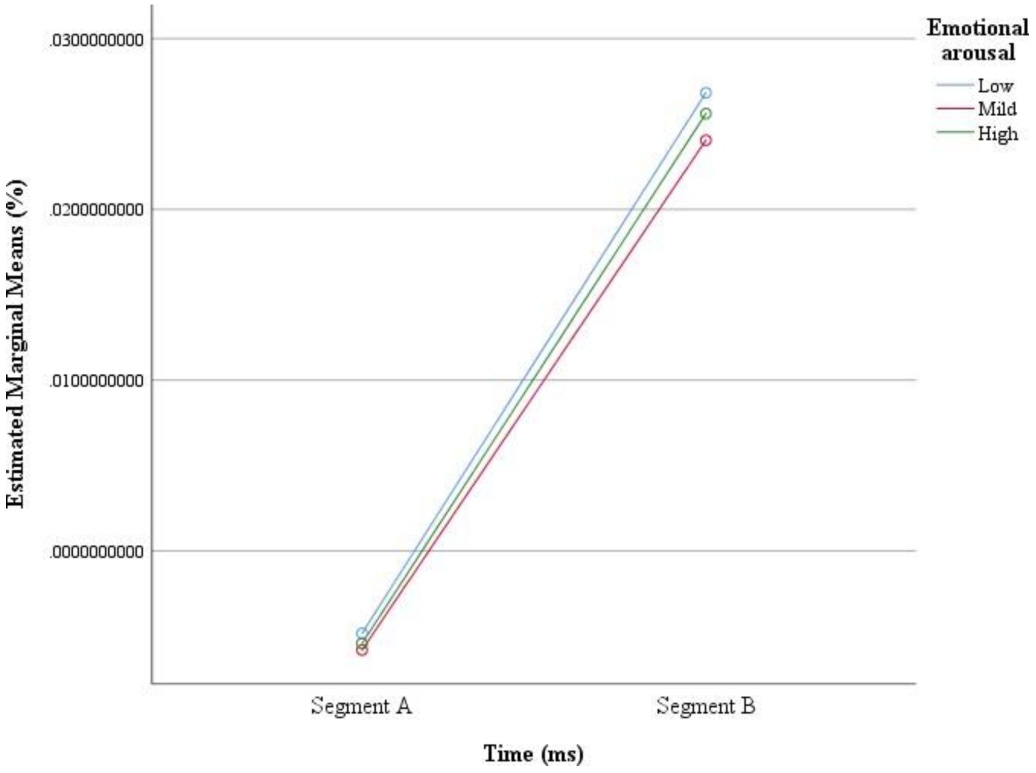


Figure 15. The average pupil dilation deviation (%) during the arousal condition

4.3.2.2 ANOVA of load and time

As stated in section 4.2.2.1, the average PD for both cognitive load conditions at both time segments is reported as % deviation and can be seen in Table 11 below.

Table 11: Descriptive statistics for load and time (ms)

Load	Time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Low	Segment A	-0.006	0.044	-0.100	0.090
	Segment B	0.020	0.042	-0.072	0.111
High	Segment A	-0.005	0.043	-0.100	0.090
	Segment B	0.032	0.042	-0.061	0.124

High cognitive load and segment B has the highest mean of 0.032% where segment A and high cognitive load has the lowest mean of -0.05%.

The repeated measures ANOVA for cognitive load and time explored the influence of load and time on PD. The results of this analysis can be seen below (Table 12). There was a significant main effect of time on PD, $F(1, 11) = 29$, p □ .001, $\eta^2 = 0.73$. There was no significant main effect of cognitive load, indicating that PD between low and high levels of load were generally the same, $F(1, 11) = 1.75$, $p = .21$, $\eta^2 = 0.14$. There was also a significant interaction effect between cognitive load and time $F(1, 11) = 34.41$, p □ .001, $\eta^2 = 0.76$., indicating that load had different effects on PD depending on the time during the 2000 ms stimulus presentation.

Table 12: Test of within-subjects effects for load and time (segments)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Load	0.00046	1.00	0.00046	1.75	0.21	0.14
Error(Load)	0.00292	11.00	0.00027			
Time	0.01143	1.00	0.01143	29.00	0.00	0.73
Error(Time)	0.00434	11.00	0.00039			
Load * Time	0.00039	1.00	0.00039	34.41	0.00	0.76
Error (Load*Time)	0.00013	11.00	0.00001			

The graph below shows the % deviation of PD across cognitive load conditions (low and high) was similar across segment A and segment B with a gradual increase. PD deviation across high load, however, was higher than that of low load (Figure 16).

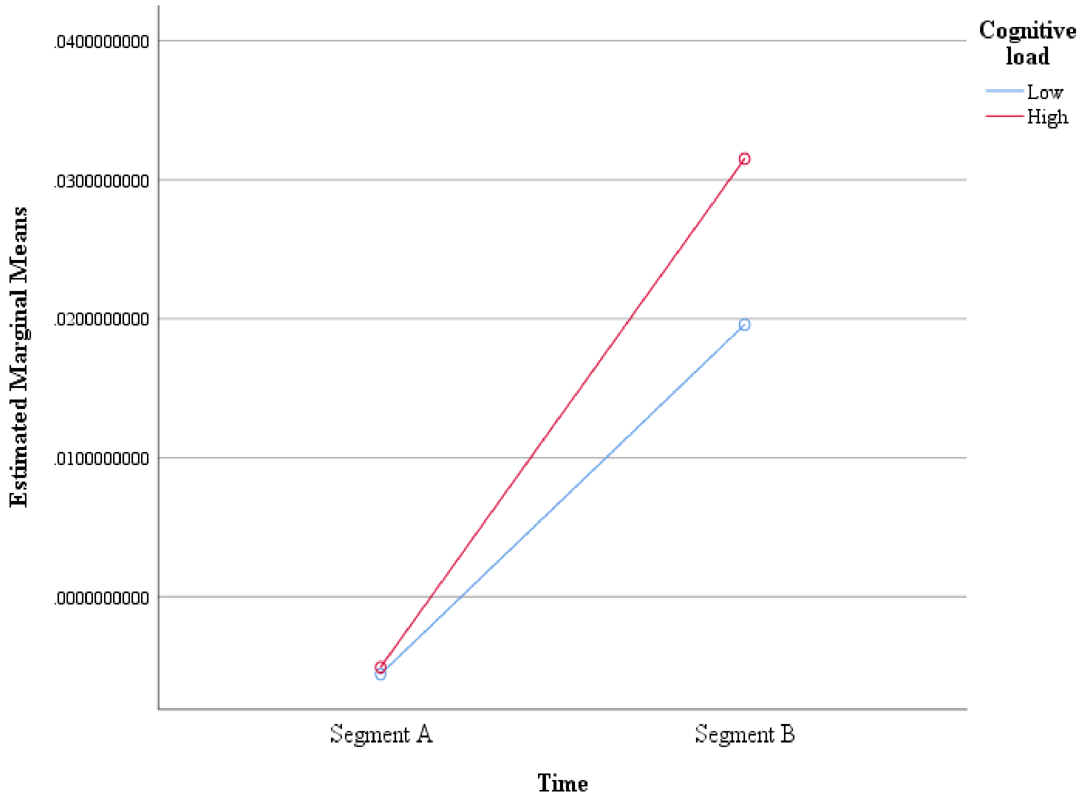


Figure 16. The average pupil dilation deviation (%) during the load condition

4.3.2.3 Emotional arousal and cognitive load

The results between time and cognitive load as well as emotional arousal and time have been presented. The major focus of the study was to look at how load and arousal conditions, when presented together, influence PD. This is what the graphs below illustrate. Note that the same time frame of 2000 ms has been used. Figure 17 below shows the PD in mm for all three levels of arousal during the low load condition. The smoothed graph shows that PD for arousal on all three levels was the lowest just before 500 ms and the highest at about 1250 ms which means that participants' pupils constricted and dilated at similar time segments.

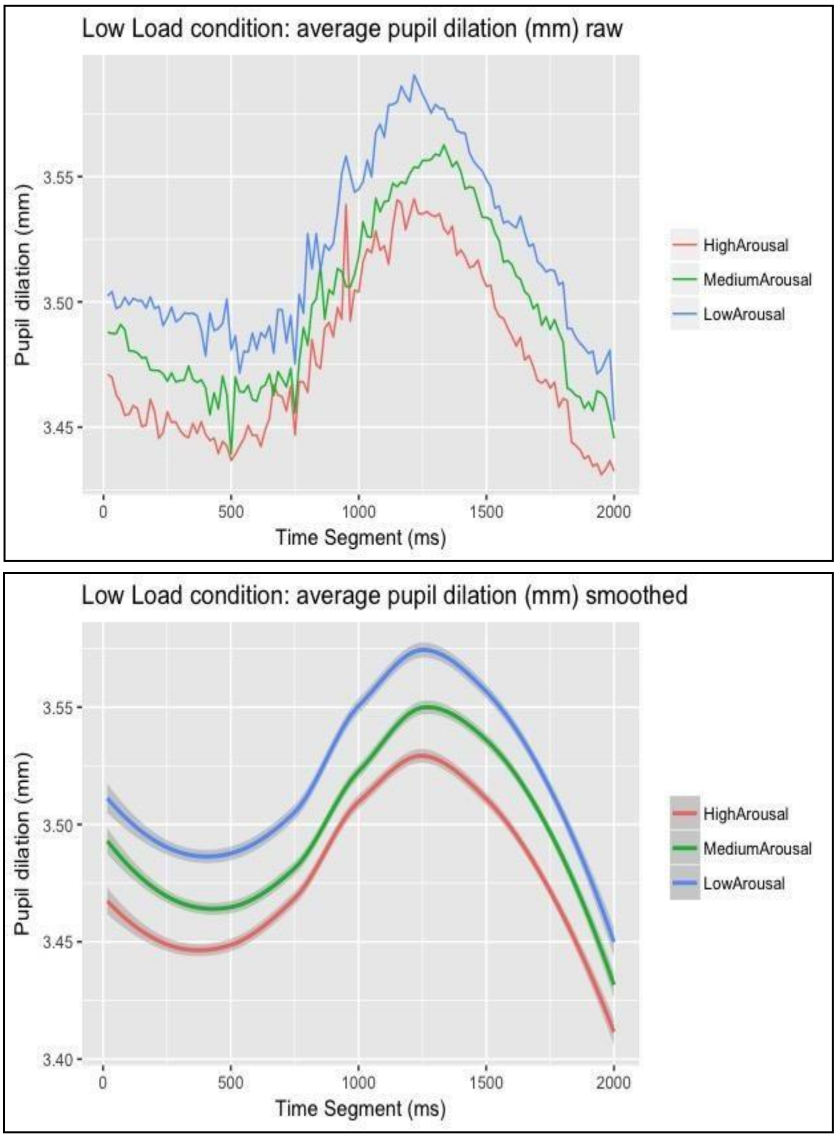


Figure 17. The average pupil dilation (mm) of the raw scores during the low load/arousal condition

Looking at the % deviation of PD, Figure 18 shows that at maximum constriction, high and medium emotional arousal has little deviation compared to low arousal. The same is true during maximum dilation at 1250 ms, with low arousal deviating more than medium and high arousal at just above 0.02%.

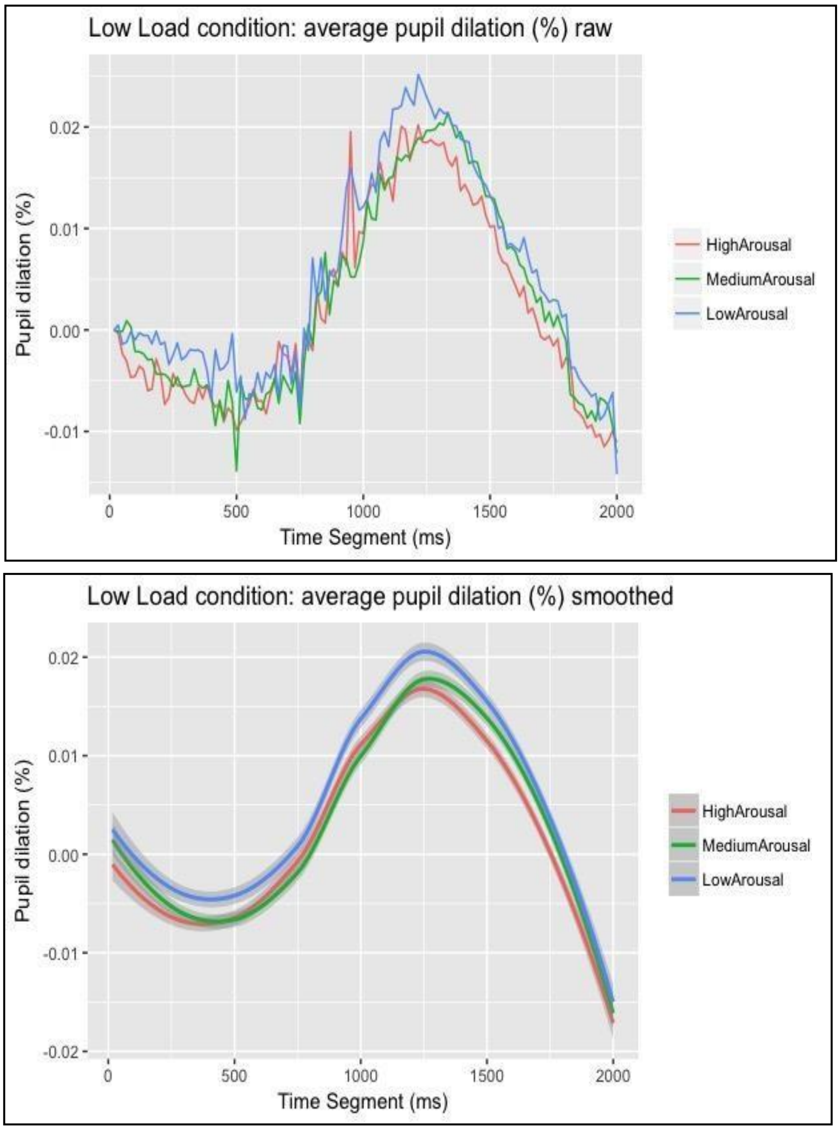


Figure 18. The average pupil dilation deviation (%) during the low load/arousal condition

The PD raw scores (mm) and % deviation graphs for emotional arousal and high cognitive load is different. Figure 19 shows the raw scores of PD. The same pattern of constriction and dilation occurs as in the low load condition where high arousal has a minimum dilation of about 3.45 and a maximum dilation of about 3.57 mm. This is much higher than low and medium arousal's minimum (□3.42 mm) and maximum (□3.54 mm) dilation.

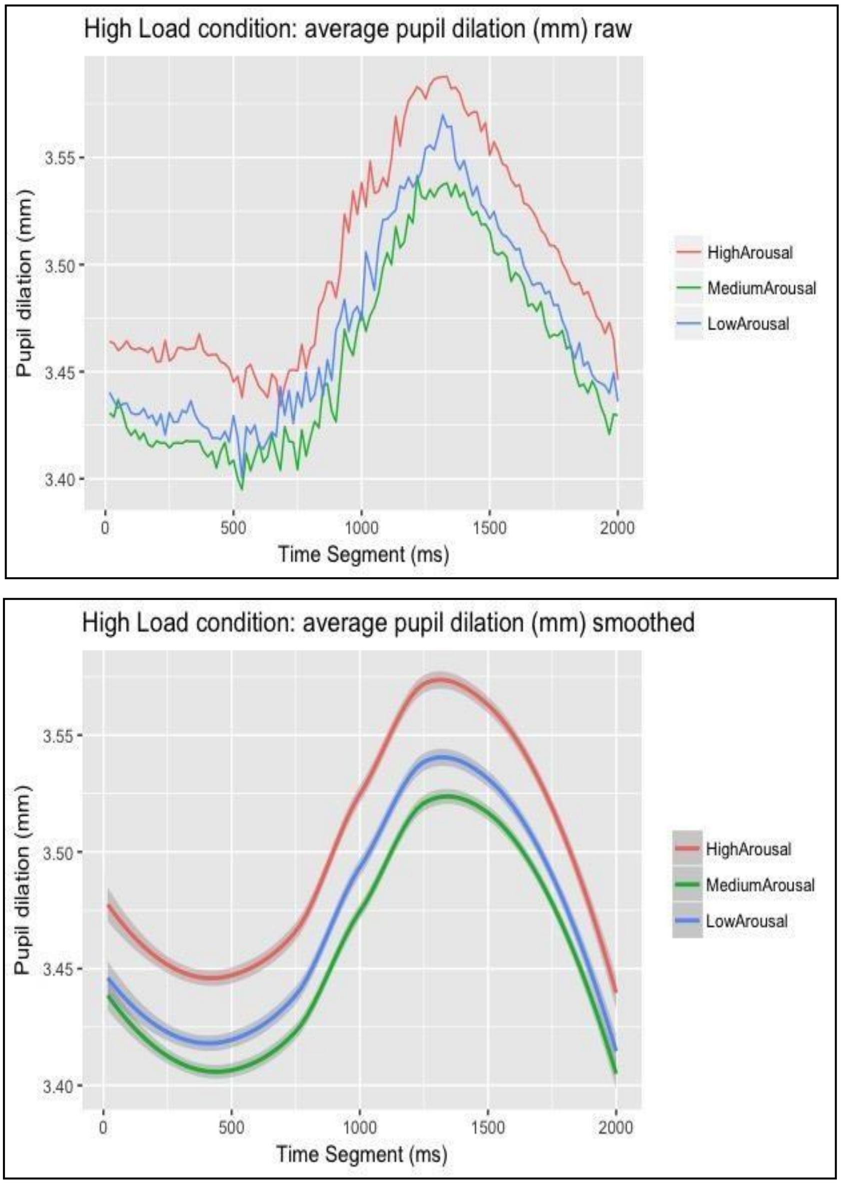


Figure 19. The average pupil dilation (mm) of the raw scores during the high load/arousal condition

The same is true for the % deviation of PD for the high load condition and emotional arousal (Figure 20). High arousal deviates more than medium and low arousal during constriction and dilation. High arousal deviates just more than 0.03% during dilation in the high load condition.

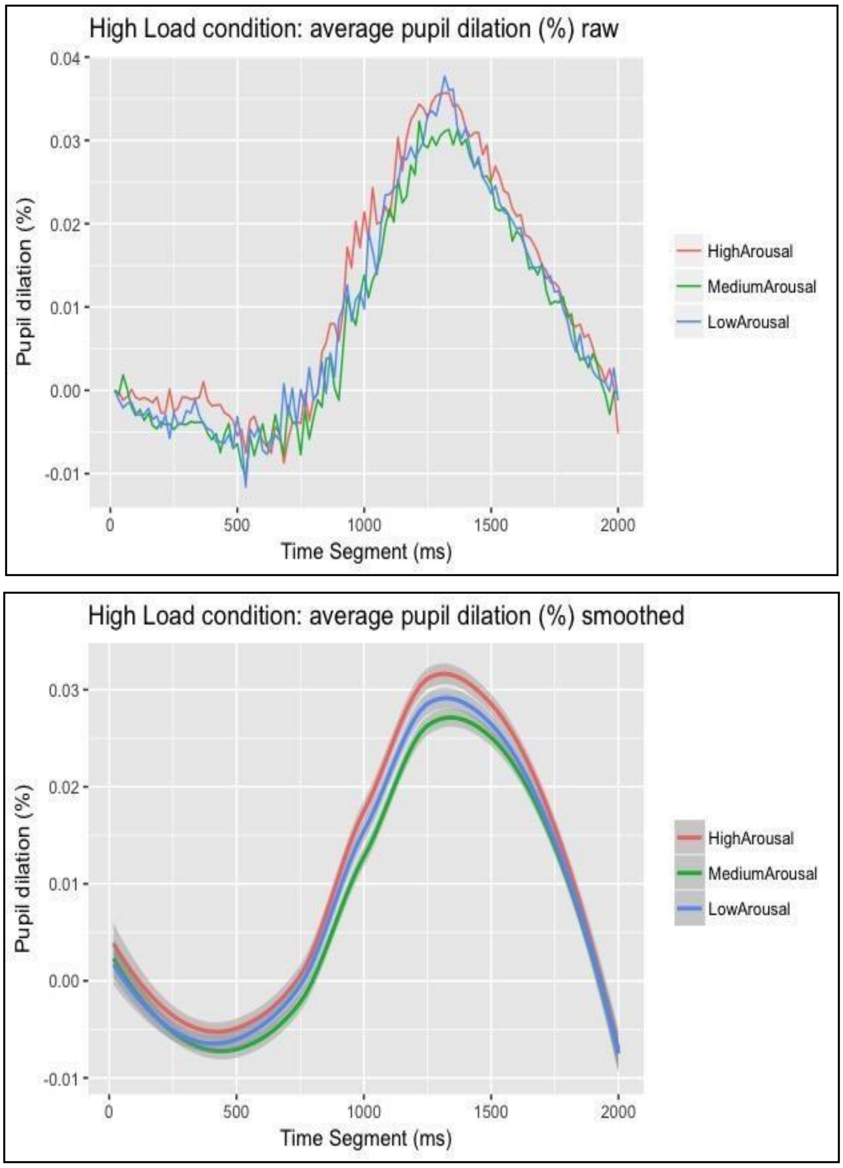


Figure 20. The average pupil dilation deviation (%) during the high load/arousal condition

PD under low and high arousal followed the same pattern of constriction and dilation. The difference between the two conditions is that PD was the most for low arousal in the low load condition and for high arousal in the high load condition.

4.3.2.4 ANOVA of arousal and load

When it came to running an ANOVA for emotional arousal and cognitive load, only segment B was run. Recall that this segment was during post stimulus exposure and the pupil's reaction to the stimulus was recorded during segment B. By using only segment B for the ANOVA, the relationship between load and arousal post stimulus exposure could be explored. Table 13 shows the average PD % deviation for all three levels of arousal during both low and high cognitive load conditions. Deviation for the high load condition is more than that of the low load condition for all levels of arousal. High load and high arousal has the highest deviation of 0.032% where low load and high arousal has the lowest PD deviation (0.018%).

Table 13: Descriptive statistics for load and arousal for time segment B

Load	Arousal	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Low	Low	0.022	0.042	-0.070	0.114
	Mild	0.019	0.042	-0.074	0.112
	High	0.018	0.041	-0.073	0.108
High	Low	0.032	0.042	-0.061	0.124
	Mild	0.029	0.041	-0.061	0.119
	High	0.033	0.044	-0.064	0.131

The repeated measures ANOVA for arousal and load explored the influence of arousal and load on PD (Table 14). Effects are reported as significant at p □ .05. There was a significant main effect of load on PD, $F(1, 11) = 6.05$, $p = 0.03$, $\eta^2 = 0.36$. No significant main effect of emotional arousal was found, $F(2, 22) = 0.17$, $p = .84$, $\eta^2 = 0.02$ which indicates that PD between low, mild and high levels of arousal were generally the same. There was also no interaction effect between emotional arousal and cognitive load, indicating that the PD between the simultaneous combination of arousal and load remained similar throughout the experiment, $F(2, 22) = 0.18$, $p = .84$, $\eta^2 = 0.02$.

Table 14: Test of within-subjects effects for load and arousal for time segment B

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Load	0.00	1	0.00	6.05	0.03	0.36
Error(Load)	0.00	11	0.00			
Arousal	0.00	2	0.00	0.17	0.84	0.02
Error(Arousal)	0.01	22	0.00			
Load * Arousal	0.00	2	0.00	0.18	0.84	0.02
Error(Load*Arousal)	0.01	22	0.00			

Figure 21 shows that the % deviation of PD was similar between low and high cognitive load under conditions of low, mild and high emotional arousal. PD during low and mild arousal increased in a similar pattern between low and high cognitive load. High arousal was different where there was a greater range in deviation between low and high cognitive load.

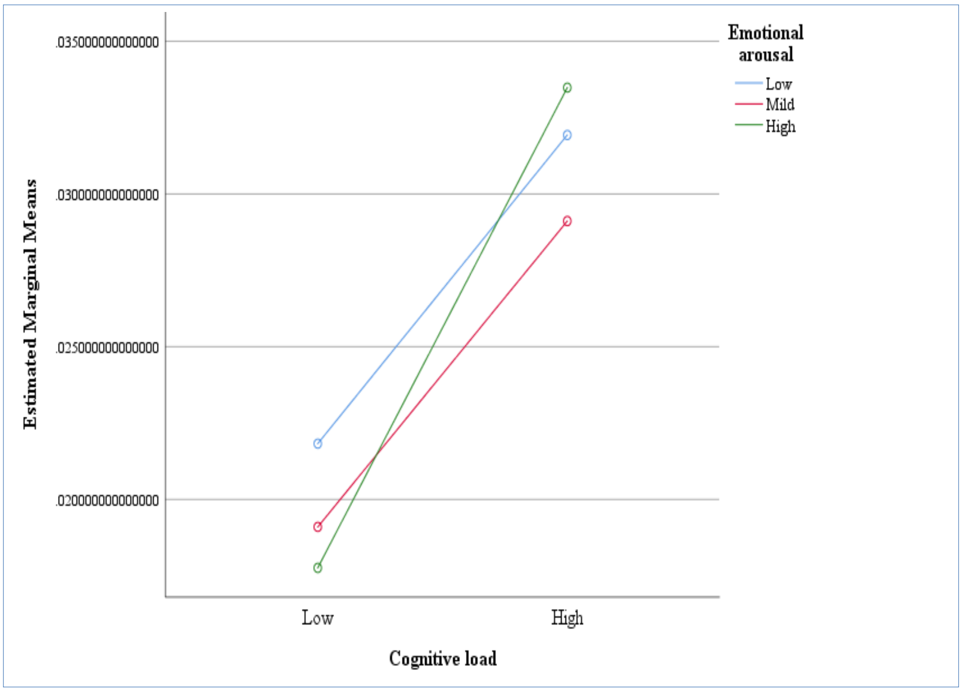


Figure 21. The average pupil dilation deviation (%) during the arousal and load condition

4.4 Chapter summary

The results were presented in two main sections. The first section focussed on participant responses, where correct and incorrect scores were explored followed by reaction times of participants throughout the study. The second section's main focus was pupil dilation where the deviation of pupil dilation during the cognitive load, emotional arousal and combined load/arousal condition were analysed. Once it had been ascertained that the assumption of sphericity underlying a repeated measures ANOVA had been met, the statistical test was carried out to investigate the effects of cognitive load and emotional arousal on making a decision.

Participant responses showed that the most correct answers came from the low load/low arousal condition and the high load/low arousal condition rendered the least correct answers. A significant main effect of cognitive load was found on participant scores which indicate that, in this study, low or high cognitive load stimuli had an impact on the participant's ability to get a correct or incorrect response. Participant response times showed that their mean reaction time to high load/high arousal stimuli was the slowest and the fastest to high load/mild arousal stimuli. A statistically significant main effect of arousal was found for reaction time which means that the level of emotional arousal influenced how long it took for participants to respond.

Pupil dilation results show that participant's pupils, regardless of condition, all followed a similar pattern of constriction just before presentation of the stimulus in each trial and then dilation post stimulus exposure. Results show a significant main effect of time on pupil dilation during the load and arousal condition separately. This proves that PD is different before stimulus exposure (time segment A) and after the participant has seen the stimulus (time segment B). A significant interaction effect between cognitive load and time indicated that load had different effects on pupil dilation depending on the time segment of the trial (segment A or B). A repeated measures ANOVA of emotional arousal and cognitive load during segment B showed that average pupil dilation deviation was the most for the high load/high arousal condition and the least for the low load/high arousal condition. A significant main effect of cognitive load on pupil dilation deviation was found. To investigate whether arousal or load acted as a moderating variable with regard to the impact of either construct on pupil dilation, the possibility of an interaction effect was examined. There was no statistically significant interaction between cognitive load and emotional arousal. These results are discussed in the following chapter.

CHAPTER 5

DISCUSSION, LIMITATIONS AND RECOMMENDATIONS

5.1 Introduction

The final chapter of this dissertation discusses the results presented in chapter four. The broad aim of this study was to investigate whether emotional arousal and cognitive load have an impact on decision making. To achieve this aim, three primary objectives were set out. Firstly, to determine how many participant responses during a decision making task was correct or incorrect. The task used was the Stroop task. Secondly, to measure reaction time (in milliseconds or ms) during the Stroop task when exposed to different levels of emotionally arousing words and cognitive loaded stimuli. Thirdly, to use pupil dilation (in millimetres or mm) as a measurement of varying levels of cognitive load and emotional arousal on separate and simultaneous occasions.

To investigate the first and second objective, the following results are discussed: a) the mean score results of the correct and incorrect responses of participants as measured by the Stroop task, b) the mean reaction times of the participants during the Stroop task, and c) the statistical significance of the main effect between cognitive load on correct and incorrect scores and between arousal and reaction time as determined by the results of the repeated measures ANOVA. To investigate the third objective, average percentage deviation of pupil dilation as well as the main and interaction effects between emotional arousal, cognitive load and time on pupil dilation, as determined by the repeated measures ANOVA, is discussed. Each of these was discussed according to hypotheses set out in section 3.2.1. Finally, the various limitations of this study are presented while also offering recommendations for areas of research that require further investigation.

5.2 The effects of correct/incorrect scores on participant responses

Participants' responses were classified as correct when the colour of the ink of the word on the screen corresponded with the colour key they selected on the keyboard and incorrect if there was no correspondence between the colour of the word and the colour key selected. This was explained in detail in section 3.5.3. Correct and incorrect responses were used as a form of control with the aim of using only the correct responses in the analysis as per previous studies using the Stroop task (Gul & Humphreys, 2015; Lamers et al., 2010; Macleod, 1998, 1991). Results show that, on average, the most correct answers were given for the low load/low arousal condition and the most incorrect answers were given for the high load/low arousal condition. Additionally, a significant main effect of cognitive load on scores ($p < .001$) was found which means that there were statistically significant differences between the scores under low load and high load conditions. However, the raw data shows that 11 of the 12 participants got majority of their answers incorrect, with only one participant getting all of the answers correct. This could mean that the combination of looking at the screen and having to select a colour key within the limited 2000 ms time frame proved to be too difficult. Because of this, all the responses were used during the data analysis. This is different from previous studies where only the correct responses were used during data analysis (Gul & Humphreys, 2015; Lamers et al., 2010; Macleod, 1991, 1998). By using all the responses during the data analysis, the main focus of the study, pupil dilation, could be analysed.

5.3 Reaction time hypotheses

Recall each hypothesis:

1) The mean response time for low emotionally arousing words will be different from high emotionally arousing words:

$$H_0: \mu_{LowArousal} = \mu_{HighArousal} : H_1: \mu_{LowArousal} \neq \mu_{HighArousal}$$

2) The mean response time for low load words will be different from high load words:

$$H_0: \mu_{LowLoad} = \mu_{HighLoad} : H_1: \mu_{LowLoad} \neq \mu_{HighLoad}$$

3) There is a two-way interaction between emotional arousal and cognitive load for mean response time:

$$H_0: A - B = 0: H_1: A - B \neq 0$$

$$\text{where } A = (\mu_{LowArousalLowLoad} - \mu_{LowArousalHighLoad}) \text{ and}$$

$$B = (\mu_{HighArousalLowLoad} - \mu_{HighArousalHighLoad})$$

As mentioned earlier, participants' reaction time on the computerised Stroop task gave an indication of their decision making. Results showed that reaction times were faster for the low load condition than for the high load condition for low and high arousal. This finding confirms hypothesis one and two. The mean response time for low load/mild arousal was the slowest at 807.56 ms. The fastest mean response time was for the low load/high arousal condition at 751.69 ms. The fastest mean response time for the high load condition was high load/high arousal at 753.35 ms. This shows that response times during the low load conditions were on average 1.66 ms faster than during the high load conditions.

Even though Tønnessen, Haugen and Shalfawi (2013) highlighted the significance of minor differences in reaction time scores and stated that a 10 ms difference may have a profound impact on the outcome of a task, the 1.66 ms difference in this study is very small. A possible explanation for the small variation in response times in this study is that participants were required to look at the stimulus on the laptop screen and then make the appropriate response on the keyboard. This results in lost time between being exposed to the stimulus and then having to look at the keyboard, find the appropriate colour key and then only make a decision.

A significant main effect of arousal on reaction time (p = .01) means that there were statistically significant differences between low, mild and high emotional arousal when it came to how quickly participants responded. This significant difference in levels of arousal corresponds with previous findings where emotionally arousing stimuli, regardless of valence, has an impact on arousal and in turn influences how long it takes to make a decision (Kousta et al., 2009: Murphy et al., 2014). There was no interaction effect between emotional arousal and cognitive load on reaction time, rejecting hypothesis three. This contradicts the researcher's hypothesis that the two constructs simultaneously utilise almost all available cognitive resources by dedicating them to the loaded and highly aroused stimulus, making it longer for a decision to be made. The lack of interaction means that arousal and load do not cause a significant effect when combined on making a decision.

5.4 Pupil dilation hypotheses

Recall each hypothesis:

4) The pupil dilation for low emotionally arousing words will be different from high emotionally arousing words:

   H_o: $\mu PD_{LowArousal} = \mu PD_{HighArousal}$: H_1: $\mu PD_{LowArousal} \neq \mu PD_{HighArousal}$

5) The pupil dilation for low load words will be different from high load words:

   H_o: $\mu PD_{LowLoad} = \mu PD_{HighLoad}$: H_1: $\mu PD_{LowLoad} \neq \mu PD_{HighLoad}$

6) There is a two-way interaction between emotional arousal and cognitive load for pupil dilation:

$$H_0: A - B = 0: H_1: A - B \neq 0$$

$$\text{where } A = (\mu PD_{LowArousalLowLoad} - \mu PD_{LowArousalHighLoad}) \text{ and}$$

$$B = (\mu PD_{HighArousalLowLoad} - \mu PD_{HighArousalHighLoad})$$

Pupil dilation (PD) was defined in chapter two as the total diameter, in millimetres, of the pupil in the eye (Porter et al., 2007; Rieger & Savin-Williams, 2012). This reading was measured using the SensoMotoric Instrument (SMI) Eye Tracker as discussed in section 3.5.4. When it came to the pattern of PD, all pupillometry graphs were similar where constriction occurred around 500 ms and dilation around 1250 ms (see Figures 11 – 21). There were very small deviation differences for all the conditions except for the cognitive load and time segment graph (Figure 14). The graph showed more than a 0.01% deviation difference between low and high cognitive load post stimulus exposure, which is much more than the average % deviation in the other conditions. The difference in PD deviation here can be explained as PD being a measure of mental effort where there is more effort during the high load than the low load condition (Beatty, 1982; Piquado et al. 2010). In other words, the more mental effort is dedicated to a specific task, the more the pupils will dilate when completing that task because pupil dilation is a measure of mental effort.

Recall that the results of PD were divided between time segment A and segment B. Segment A was between 417 ms and 734 ms and is viewed as the segment prior to a response being made at its lowest point. Segment B was between 1167 ms and 1417 ms and viewed as the segment after the participant had been exposed to the stimulus at its highest point and had made a response.

Looking at emotional arousal and the time segments, a statistically significant main effect of time segments was found to have an impact on PD (p = 0.001). Pupil dilation was impacted by the time at which the stimulus was presented and not by the intensity of the emotional stimulus. The same is true when looking at cognitive load and time segments where a significant main effect of time had an impact on PD ($p < 0.001$). This main effect of time corresponds to previous findings where exposure to new stimuli in a task increased pupil dilation (Kahneman & Beatty, 1966; Piquado et al., 2010; Porter et al., 2007). Every time a new stimulus or word came up in the Stroop task, which occurred during time segment B, the cognitive system allocated available resources in attempt to process that stimulus as quickly and effectively as possible. This allocation results in a system that is either loaded or aroused causing the pupils to dilate. A significant main effect of both arousal and load was expected but did not come up in the results section. This contradicts studies that state that emotional arousal has a direct impact (Bradley et al., 2008). A possible reason for this is that the eye tracker's calibration was done only when participants were looking at the laptop screen; eye tracking was limited when they looked away from the screen. Some participants looked down at the keyboard when they had to press a colour key and as a result some eye tracking data could have been lost.

A statistically significant interaction effect between cognitive load and time on PD was found ($p < 0.001$). This means that the simultaneous effect of load and time on PD is significantly greater than the effect of load or time on its own. This finding rejects hypothesis six where it was expected that here would be a two-way interaction between emotional arousal and cognitive load for pupil dilation and not cognitive load and the time of the stimulus presentation. As discussed in section 2.4, the degree of pupil dilation indicates how mentally demanding a task is where the more difficult the task becomes, the more the pupils will dilate (Piquado et al., 2010). Additionally, because each trial was divided in time segment A (prior stimulus exposure) and segment B (post stimulus exposure), the researcher expected this interaction to occur because segment B introduced a new stimulus, increasing the load during that segment and therefore increasing pupil dilation. This interaction effect means that low or high cognitive load together with either segment A or B have more of an effect on PD than each level of the variables exclusively.

The results of the ANOVA between emotional arousal and cognitive load on PD focussed solely on data collected from segment B. The reason for this is connected to the main research question: What is the impact of emotional arousal and cognitive load on decision making? To investigate this, segment B was the most appropriate segment to look at because it was during this time that the cognitive system was aroused and loaded simultaneously. The results show that a statistically significant main effect of cognitive load on PD was found during the load/arousal condition ($p = 0.03$), confirming hypothesis five but rejecting hypothesis four. Under a condition of arousal and load, cognitive load was the only variable that had a significant impact on PD. As mentioned earlier in this section, it is expected for cognitive load to have a significant effect on PD because as task demands increase so does cognitive load and therefore pupil dilation (Kahneman & Beatty, 1966; Piquado et al., 2010). However, the researcher also expected an interaction effect between load and arousal, which there was not. Chapter two discussed how emotional arousal and cognitive load each has an impact on PD (Ariely & Loewenstein, 2006; Berggren et al., 2012;

Bradley et al., 2008; Piquodo et al., 2010; Rieger & Savin-Williams, 2012). Previous studies have found that the more aroused the cognitive system is, the more pupils dilate (Berggren et al., 2012; Piquodo et al., 2010; Rieger & Savin-Williams, 2012). The same is true for cognitive load: the more loaded the cognitive system is, the bigger the pupil size (Kahneman, 1973; Kelley & Lavie, 2011; Rieger & Savin-Williams, 2012). Therefore, when presented simultaneously, the researcher expected these two constructs to have more of an effect on PD than either of them does alone.

The experimental procedure instructions include a debriefing session at the end of the experiment. When asked how they experienced the experiment, majority of the participants told the researcher that they struggled a little with the congruent/incongruent conditions (the high and low cognitive load condtions). No mention was made about the swear or sexual words presented which the researcher found interesting.

A possible explanation of the lack of interaction between load and arousal, and the significant main effect of load on PD during the load/arousal condition is that, as mentioned in section 1.2, society has become desensitised to explicit words which would usually have caused a much higher level of arousal than it did in this study (Berggren et al., 2012). Explicit words, including swear and sexually related words, have become a reality in modern society where the use of highly arousing stimuli in forms of media have become a social norm (Jeong et al., 2010; Parkes et al., 2013). This could be the reason why arousal did not have a significant impact on PD.

5.5 Conclusion

The main aim of this study was to determine whether cognitive load and emotional arousal have an impact on decision making. To achieve the aim, a quantitative design was implemented to test the effects of emotional arousal and cognitive load on pupil dilation and reaction time. Results show that there was no interaction between cognitive load and emotional arousal for both pupil dilation and reaction time. This finding does not align with previous research. A statistically significant difference was found between cognitive load and pupil dilation as well emotional arousal and reaction time. This study may provide insight into the way in which, when presented together, emotional arousal and cognitive load influence decision making As mentioned, many studies have investigated the relationship between cognitive load or emotional arousal and pupil dilation, while this study focussed on each construct separately as well as simultaneously.

The results of this study suggest that under a highly loaded and emotionally arousing condition, only cognitive load had an impact on decision making. However, this is an area that requires more research before any definitive claims can be made. This is particularly significant in a context as diverse and multicultural as South Africa.

5.6 Limitations of the current study

The results obtained in this study should be interpreted within the context of its limitations. These limitations are discussed below.

5.6.1 Sample size

The law of large numbers in statistics states that the larger the sample size, the more accurately it represents the population (Gravetter & Forzano, 2012). This law was not abided by in the current study with a relatively small sample of 12 participants. According to the literature, prior research on emotional arousal and cognitive load contained varied sample sizes where Benoni and Tsal's (2010) and Murphy and colleagues' (2014) studies contained 23 and 26 participants respectively but other studies contained more than 100 participants (Missier et al., 2012; Rieger & Savin-Williams, 2012). As discussed in section 3.7.3, the power of a statistical test is influenced by a small sample size (Shadish et al., 2002). This may have resulted in low statistical power which, in turn, may have impacted the statistical conclusion validity of the study. Another consequence of a small sample size is that the researcher is more prone to a Type II error. That is, when the results of the sample do not show a significant effect when a real effect occurs in the population (Field, 2013).

5.6.2 Sample bias

The sample was severely biased in favour of females and because of that the results may not be generalizable. Prior studies normally have more gender balanced samples which makes it unclear whether this study can be compared to other studies (De Jager, 2015). The restriction of age also meant that the sample ended up being homogeneous in age. Even though there is always a trade-off between control and generalisability in experimental settings, this experiment aimed at maximising internal validity and controlling for age so that it could not serve as an alternate explanation for the results because, as discussed in the literature, age is known to influence response times and cognitive processing (Yoder et al., 2010). The consequence of this is that the ability to generalise the results are severely limited, as the sample consisted of mostly females aged 19 to 22 years of age.

5.6.3 The use of the eye tracker

The use of the eye tracker during this study was problematic for two main reasons. Firstly, the eye tracker limited the number of participants that could be tested during each experimental session to one. Even though this made data collection time consuming for the researcher, the eye tracker was needed to provide invaluable data on pupil dilation as a measurement of both cognitive load and emotional arousal which is what the study's main focus was. This is the principle justification for the use of the time consuming device.

Secondly, even though the eye tracker was non-invasive and mounted to the bottom of the laptop, this placement created a challenge during the experiment. Calibration and pupil dilation data collection occurred only when participants were looking at the laptop screen. During the experiment, the researcher realised that even though participants kept their eyes on the screen during stimulus exposure, majority looked down at the keyboard when they wanted to make a response. There were 60 trials per participant and 720 trials in total which means that because the eye tracker only recorded data if participants were looking at the screen, there was a possibility that data was lost for a few milliseconds for 720 times throughout the experiment.

5.7 Recommendations for future research

It is suggested that future studies pay more attention to South Africa's rich cultural context when studying the impact of emotional arousal and cognitive load on decision making. Not only would this broaden the scope of South African research but it would also bring unique challenges related to South Africans to light.

If high emotionally arousing words, like explicit swear words and words of a sexual connotation, cannot elicit a significant effect on pupil dilation, what then can be used to elicit a significant emotional arousal effect? The researcher recommends using pictures instead of words. Using pictures may possibly elicit a stronger arousal than words have.

Methodologically, using random sampling instead of convenience sampling would lead to a more representative sample and is therefore recommended. This will also increase the generalisability of the study and its findings. Obtaining a larger sample will also result in a more diverse sample population which will counter the effects of gender (which was a limitation in this study). Lastly, the researcher recommends allowing participants sufficient practise when using a computerised version of the Stroop task and a laptop-mounted eye tracker. A suggested ratio would be to run a practise session until participants get 80% of the trials correct before actually starting the experiment instead of a set number of trials as was done in this study. This would get them used to the task and the process as well as the positioning of the colour keys on the keyboards.

References

Acharya, A. S., Prakash, A., Saxena, P., & Nigam, A. (2013). Sampling: Why and how of it. *Indian Journal of Medical Specialities, 4*(2), 330-333. doi: 10.7713/ijms.2013.0032

Adolphs, R., Tranel, D., Hamann, S., Young, A.W., Calder, A.J., Phelps, E.A., Anderson, A., Lee, G.P., Damasio, A.R. (1999). Recognition of facial emotion in nine individuals with bilateral amygdala damage. *Neuropsychologia 37*(10), 1111–1117. doi: 10.1016/s0028-3932(99)00039-1

Afsaneh, Z., Alireza, Z., Mehdi, T., Farzad, A., Reza, Z. M., Mehdi, M., & Mojtaba, K. S. (2012). Assessment of selective attention with CSCWT (computerized Stroop color-word test) among Children and Adults. *Education Review, 1,* 121-127.

Anderson & Bushman, 2002 Anderson, C. A., & Bushman, B. J. (2002). Human aggression. *Annual Review of Psychology*, 53, 27–51. doi: 10.1146/annurev.psych.53.100901.135231

Aramide, K. A., Ladipo, S. O., & Adepoju, T. O. (2015). Do social media utilisation and addiction influence undergraduate students' self-perception? A case study of university of Ibadan, Nigeria. *Journal of Emerging Trends in Educational Research and Policy Studies, 6*(7), 271-277.

Arce, E., & Santisteban, C. (2006). Impulsivity: A review. *Psicothema, 18*(2), 213-220. Retrieved from http://www.psicothema.com/pdf/3200.pdf

Argyris, C. (1976). Single-Loop and Double-Loop Models in Research on Decision Making. *Administrative Science Quarterly, 21*(3), 363-375. doi: 10.2307/2391848

Ariely, D., & Loewenstein, G. (2006). The heat of the moment: The effect of sexual arousal on sexual decision-making. *Journal of Behavioural Decision Making, 19*(1), 87-98. doi: 10.1002/bdm.501

Artino, A.R. Jr. (2008). Cognitive load theory and the role of learner experience: An abbreviated review for educational practitioners. *AACE Journal, 16*(4), 425-439. Retrieved from http://eric.ed.gov/?id=EJ817820

Aston-Jones, G., Cohen, J.D. (2005). An integrative theory of locus coeruleus-norepinephrine function: adaptive gain and optimal performance. *Annual Review of Neuroscience 28*(1), 403–450. doi: 10.1146/annurev.neuro.28.061604.135709

Baddeley, A. (2003). Working memory: Looking back and looking forward. *Nature Reviews Neuroscience, 4*(10), 829–839. doi: 10.1038/nrn1201

Beach, L. R., & Mitchell, T. R. (1978). A contingency model for the selection of decision strategies. *Academy of Management Review, 3*, 439–449. doi: 10.21236/ada061904

Beatty, J. (1982). Task-evoked pupillary responses, processing load, and the structure of processing resources. *Psychological Bulletin, 91*(2), 276–292. doi: 10.1037//0033-2909.91.2.276

Bechara, A., Damasio, H., Tranel, D., & Anderson, W. S. (1998). Dissociation of working memory from decision making within the human prefrontal cortex. *The Journal of Neuroscience, 18*(1), 426–437. doi:10.1523/jneurosci.18-01-00428.1998

Bechara, A., Damasio, H., Tranel, D., & Damasio, A. R. (2005). The Iowa Gambling Task and the somatic marker hypothesis: Some questions and answers. *Trends in Cognitive Sciences, 9*(4), 159–162. doi: 10.1016/j.tics.2005.02.002

Benoni, H., & Tsal, Y. (2010). Where have we gone wrong? Perceptual load does not affect selective attention. *Vision Research, 50*(13), 1292-1298. doi: 10.1016/j.visres.2010.04.018

Berggren, N., Koster, E. H. W., & Derakshan, N. (2012). The effect of cognitive load in emotional attention and trait anxiety: An eye movement study. *Journal of Cognitive Psychology, 24*(1), 79-91. doi: 10.1080/20445911.2011.618450

Bernstein, D. A., Penner, L. A., Clarke-Stewart, A., & Roy, E. J. (2006). *Psychology* (7th. ed.). New York, NY: Houghton Mifflin Company.

Bradley, M.M., Miccoli, L., Escrig, M.A., & Lang, P.J. (2008). The pupil as a measure of emotional arousal and autonomic activation. *Psychophysiology, 45*(4), 602-607. doi: 10.1111/j.1469-8986.2008.00654.x

Brünken, R., Plass, J. L., & Leutner, D. (2004). Assessment of cognitive load in multimedia learning with dual-task methodology: auditory load and modality effects. *Instructional Science, 32*(1-2), 115-132.

Busemeyer, J. R., & Townsend, J. T. (1993). Decision field theory: A dynamic-cognitive approach to decision making in an uncertain environment. *Psychological Review, 100*(3), 432–459. doi: 10.1037//0033-295x.100.3.432

Byrnes, J.P. (1998). *The nature and development of decision making*. Mahwah, NJ: Erlbaum

Cannon-Bowers, J.A., & Salas, E. (2002). Individual and team decision making under stress: Theoretical underpinnings. In J.A. Cannon-Bowers & E. Salas (Eds.), *Making decisions under stress* (pp. 1738). Washington, DC: American Psychological Association.

Cannon-Bowers, J.A., Salas, E., & Pruitt, J.S. (1996). Establishing the boundaries of a paradigm for decision-making research. *Human Factors, 38*(2), 193-205. doi: 10.1177/001872089606380202

Choi, H., van Merriënboer, J. J. G., & Paas, F. (2014). Effects of the physical environment on cognitive load and learning: towards a new model of cognitive load. *Educational Psychology Review, 26*(2), 225-244. doi:10.1007/s10648-014-9262-6

Christensen, L. B., Johnson, B., & Turner, L. A. (2015). *Research Methods, Design and Analysis* (11th ed.). South Alabama: Pearson.

Cohen, M.D., & March, J. G.. (1974). *Leadership and Ambiguity: The American College President*. New York: McGraw Hill Book Co.

Cohen, M.S. (1995). The bottom line: Naturalistic decision aiding. In G.A. Klein, J. Orasanu, R. Calderwood, & C.E. Zsambok (Eds.), *Decision making in action: Models and methods* (pp. 265-269). Norwood, NJ: Ablex.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings*. Chicago: Rand-McNally

Corn, A. L., & Erin, J. N. (2010). *Foundations of low vision: Clinical and functional perspectives (*2nd ed.*).* New York: AFB Press.

Costafreda, S. G., Brammer, M. J., David, A. S., & Fu, C. H. (2008). Predictors of amygdala activation during the processing of emotional stimuli: a meta-analysis of 385 PET land fMRI studies. *Brain Research Revolution, 58*(1), 57-70.

Cowan, N. (2001). Metatheory of storage capacity limits. *Behavioral and Brain Sciences, 24*(1), 154-176. doi: 10.1017/S0140525X0161392X.

Davis, M., & Whalen, P.J. (2001). The amygdala: Vigilance and emotion. *Molecular Psychiatry, 6*(1), 13–34. doi: 10.1038/sj.mp.4000812

De AcedoLizarraga, M. L. S., De AcedoBaquedano, M. T. S., Oliver, M. S., & Closas, A. (2009). Development and validation of a decision-making questionnaire. *British Journal of Guidance & Counselling*, *37*(3), 357-373. doi: 10.1080/03069880902956959

De Jager, G. T. (2015). Investigating stimulus salience and perceptual load interaction using a hybrid-visual search flanker task (Masters mini-dissertation). Retrieved from http://hdl.handle.net/2263/53398

De Lange, F. P., Rahnev, D. A., Donner, T. H., & Hakwan, L. (2013). Prestimulus Oscillatory Activity over Motor Cortex Reflects Perceptual Expectations. *Journal of Neuroscience, 33*(4),1400-1410. doi: 10.1523/JNEUROSCI.1094-12.2013

Del Missier, F., Mäntylä, T., & De Bruin, W. B. (2010). Executive functions in decision making: An individual differences approach. *Thinking & Reasoning, 16*(2), 69–97. doi: 10.1080/13546781003630117

Del Missier, F., Mäntylä, T., & De Bruin, W. B. (2012). Decision making competence, executive functioning, and general cognitive abilities. *Journal of Behavioural Decision Making, 25*(4), 331-351. doi: 10.1002/bdm.731

Deutsch, J., & Deutsch, G. (1963). Attention: Some theoretical considerations. *Psychological Review, 70*(1),80-90. doi: 10.1037/h0039515

DeVon, H. A., Block, M. E., Moyle-Wright, P. , Ernst, D. M., Hayden, S. J., Lazzara, D. J., Savoy, S. M. & Kostas-Polston, E. (2007). *A Psychometric Toolbox for Testing Validity and Reliability. Journal of Nursing Scholarship, 39*(2), 155-164. doi: 10.1111/j.1547-5069.2007.00161.x

DiBonaventura, M. D., Erblich, J., Sloan, R. P., & Bovbjerg, D. H. (2010). A Computerized Stroop Task to Assess Cancer-Related Cognitive Biases. Behavioral Medicine, 36(2), 37-43. doi: 10.1080/08964280903521321

Dobešová, Z., & Malcík, M. (2015). Workflow diagrams and pupil dilatation in eye-tracking testing. *2015 13th International Conference on Emerging eLearning Technologies and Applications (ICETA)*, 1-6. doi: 10.1109/iceta.2015.7558460

Donner, T. H., Siegal, M., Oostenveld, R., Fries, P., Bauer, M., & Engel, A. K. (2007). Population activity in the human dorsal pathway predicts the accuracy of visual motion detection. *Journal of Neurophysiology, 98*(1), 345-359. doi: 10.1152/jn.01141.2006

Duncan, J. (1980). The locus of interference in the perception of simultaneous stimuli. *Psychological Review, 87*(3), 272-300. doi: 10.1037//0033-295x.87.3.272

Duncan, J., & Humphreys, G. W. (1989). Visual search and stimulus similarity. *Psychological Review, 96*(3), 433-458. doi: 10.1037//0033-295x.96.3.433

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review 66*(3), 183–201. doi: 10.1037/h0047707

Eide, P., Kemp, A., Silberstein, R. B., Nathan, P. J., & Stough, C. (2010). Test-retest reliability of the emotional stroop task: examining the paradox of measurement change. *The Journal of Psychology, 136*(5), 514-520. doi: 10.1080/00223980209605547

Engelhardt, P. E., Ferreira, F., & Patsenko, E. G. (2018). Pupillometry reveals processing load during spoken language comprehension. *The Quarterly Journal of Experimental Psychology, 63*(4), 639–645. doi: 10.1080/17470210903469864

Fernández-Marcos, T., De La Fuente, C., & Santacreu, J. (2017). Test–retest reliability and convergent validity of attention measures. *Applied Neuropsychology: Adult, 25*(5), 464-472. doi: 10.1080/23279095.2017.1329145

Fiedler, S., & Glöckner, A. (2012). The dynamics of decision making in risky choice: An eye-tracking analysis. *Frontiers in Psychology, 3*, 1–18. doi: 10.3389/fpsyg.2012.00335

Field, A. P. (2013). *Discovering statistics using IBM SPSS statistics: And sex and drugs and rock 'n roll* (4th ed.). Los Angeles: Sage.

Frederick, S. (2005). Cognitive reflection and decision making. *The Journal of Economic Perspectives, 19*(4), 24–42. doi: 10.1257/089533005775196732

García-Pérez, M. A. (2012). Statistical conclusion validity: Some common threats and simple remedies. *Frontiers in Psychology, 3,* 17-27. doi: 10.3389/fpsyg.2012.00325

Gatti, S. V., & Egeth, H. E. (1978). Failure of spatial selectivity in vision. *Bulletin of the Psychonomic Society, 11*(3), 181-184. doi: 10.3758/bf03336801

Gigerenzer, G., & Goldstein, D. G. (1996). Reasoning the fast and frugal way: Models of bounded rationality. *Psychological Review, 103*(4), 650–669. doi: 10.1037//0033-295x.103.4.650

Glöckner, A., & Betsch, T. (2008). Modeling option and strategy choices with connectionist networks: Towards an integrative model of automatic and deliberate decision making. *Judgment and Decision Making, 3*(3), 215–228

Glöckner, A., & Herbold, A. K. (2011). An eye-tracking study on information processing in risky decisions: Evidence for compensatory strategies based on automatic processes. *Journal of Behavioral Decision Making, 24*(1), 71–98. doi: 10.1002/bdm.684

Goldstein, E. B. (2011). *Cognitive Psychology* (3rd ed.). London: Wadsworth Cengage Learning.

Gooch, C. M., Stern, Y., & Rakitin, B. C. (2009). Evidence for age-related changes to temporal attention and memory from the choice time production task. *Aging, neuropsychology and cognition*, *16*(3), 285-310. doi 10.1080/13825580802592771

Gotlib, I. H., & McCann, C. D. (1984). Construct accessibility and depression: An examination of cognitive and affective factors. *Journal of Personality and Social Psychology, 47*(2), 427-439. doi: 10.1037//0022-3514.47.2.427

Gravetter, F. J., &Forzano, L. B. (2012). *Research Methods for the Behavioural Sciences* (4th ed.). Belmont: Wadsworth Cengage Learning.

Gul, A., & Humphreys, W. (2015). Practice and colour-word integration in Stroop interference. *Psicológica*, *36*(1), 37-67.

Gwizdka, J. (2010). Using Stroop task to assess cognitive load. In *Proceedings of the 28th Annual European Conference on Cognitive Ergonomics* (pp. 219-222). ACM, NY: New York.

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology,90*(3), 414-434. doi: 10.1037/0022-0663.90.3.414

Harris, P. (2008). *Designing and Reporting Experiments in Psychology* (3rd ed.). Berkshire: Open University Press.

Hatfield-Eldred, M. R., Skeel, R. L., & Reilly, M. P. (2015). Is it random or impulsive responding? The effect of working memory load on decision-making. *Journal of Cognitive Psychology*, *27*(1), 27-36. doi: 10.1080/20445911.2014.982127

Hazan-Liran, B., Miller, P. (2017). Stroop-like effects in a new-code learning task: A cognitive load theory perspective. *The Quarterly Journal of Experimental Psychology,* 70(9), 1878-1891. doi: 10.1080/17470218.2016.1214845

Hebb, D. O. (1958). The motivating effects of exteroceptive stimulation. *American Psychologist,13*(3), 109-113. doi: 10.1037/h0048220

Hebb, D. O. (1966). *A textbook of psychology* (2nd ed.). London: WB Saunders

Hess, E. H., & Polt, J. M. (1964). *Pupil size in relation to mental activity during simple problem solving. Science, 143*(3611), 1190–1192. doi: 10.1126/science.143.3611.1190

Hinson, J. M., Jameson, T. L., & Whitney, P. (2003). Impulsive decision making and working memory. Journal of Experimental Psychology. *Learning, Memory, and Cognition, 29*(2), 298–306. doi: 10.1037/0278-7393.29.2.298

Holland B. J., Siderov, J. (1999). Repeatability of measurements of interpupillary distance. Ophthalmic and Physiological Optics, 19(1), 74–78. doi: 10.1046/j.1475-1313.1999.00400.x

Hollender, N., Hofmann, C., Deneke, M., & Schmitz, B. (2010). Integrating cognitive load theory and concept of human-computer interaction. *Computers in Human Behaviour, 26*(6),1278-1288. doi:10.1016/j.chb.2010.05.031

Holmqvist, K., Nyström, M., & Mulvey, F. (2012). Eye tracker data quality: what it is and how to measure it. *In Proceedings of the Symposium on Eye Tracking Research and Applications* (pp. 45-52). ACM, NY: New York.

Hyona, J., Tommola, J., & Alaja, A. M. (1995). Pupil dilation as a measure of processing load in simultaneous interpretation and other language tasks. *Quarterly Journal of Experimental Psychology Section A, 48*(3), 598–612. doi: 10.1080/14640749508401407

IBM Corp. (2016). *IBM SPSS Statistics for Windows (Version 25).* Armonk, NY: IBM Corp.

Ishihara, S. (1972). *Ishihara tests for colour-blindness*. Tokyo: Kanehara & Co.

Jeong, S., Hwang, Y., & Fishbein, M. (2010). Effects of exposure to sexual content in the media on adolescent sexual behaviours: The moderating role of multitasking with media. *Media Psychology, 13*(3), 222-242. doi: 10.1080/15213269.2010.502872

Jiang B, Ramamirtham R. (2005). *The adaptive effect of narrowing the interocular separation on the AC/ A ratio. Vision Research, 45*(20), 2704–2709. doi: 10.1016/j.visres.2005.03.016

Kahneman, D. & Beatty, J. (1966). Pupil diameter and load on memory. *Science, 154*(3756), 1583-1585. doi: 10.1126/science.154.3756.1583

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice-Hall.

Kahneman, D. (2011). *Thinking fast and slow.* Penguin: Oxford

Kahneman, D., & Chajczyk, D. (1983). Tests of the automaticity of reading: Dilution of Stroop effects by color-irrelevant stimuli. *Journal of Experimental Psychology: Human Perception and Performance, 9*(4), 497-509. doi: 10.1037//0096-1523.9.4.497

Kelley, T.A., & Lavie, N. (2011). Working memory load modulates distractor competition in primary visual cortex. *Cerebral Cortex, 21*(3), 659-665. doi: 10.1093/cercor/bhq139

Kelly, S. P., & O’Connell, R. G. (2013). Internal and external influences on the rate of sensory evidence accumulation in the human brain. *The Journal of Neuroscience, 33*(50),19434-19441. doi: 10.1523/JNEUROSCI.3355-13.2013

Kistler, M. E., & Lee, M. J. (2009). Does exposure to sexual hip-hop music videos influence the sexual attitudes of college students? *Mass Communication and Society, 13*(1), 67-86. doi: 10.1080/15205430902865336

Kooiker, M.J.G., Pel, J. J.M., Verbunt, H.J.M., De Wit, G.C., Van Genderen, M.M., Van der Steen, J. (2016). Quantification of visual function assessment using remote eye tracking in children: Validity and applicability. *Acta Ophthalmologica, 94*(6), 599–608. doi: 10.1111/aos.13038

Kousta, S., Vinson, D. P., & Vigliocco, G. (2009). Emotion words, regardless of polarity, have a processing advantage over neutral words. *Cognition*, 1-9. doi: 10.1016/j.cognition.2009.06.007

Krcmar, M., & Cingel, D. P. (2014). Parent–child joint reading in traditional and electronic formats. *Media Psychology, 17*(3), 262–281. doi: 10.1080/15213269.2013.840243

Lairio, M., Puurkari, S., & Kouvo, A. (2013). Studying at university as part of student life and identity construction. *Scandinavian Journal of Educational Research, 57*(2), 115-131. doi: 10.1080/00313831.2011.621973

Lamers, M. J., Roelofs, A., & Rabeling-Keus, I. M. (2010). Selective attention and response set in the Stroop task. *Memory & Cognition*, *38*(7), 893-904. doi: 10.3758/mc.38.7.893

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology: Human Perception and Performance, 21*(3), 451-468. doi: 10.1037//0096-1523.21.3.451

Lavie, N. (2001). The role of capacity limits in selective attention: Behavioral evidence and implications for neural activity. In J. Braun & C. Koch (Eds.), *Visual attention and cortical circuits* (pp. 49-68). Cambridge, MA, US: The MIT Press.

Lavie, N., & Tsal, Y. (1994). Perceptual load as a major determinant of the locus of selection in visual attention. *Perception and psychophysics, 56*(2), 183-197. doi: 10.3758/bf03213897

Lavie, N., Hirst, A., De Fockert, J. W., & Viding, E. (2004). Load theory of selective attention and cognitive control. *Journal of Experimental Psychology: General, 133*(3), 339-354. doi: 10.1037/0096-3445.133.3.339.

LeDoux, J. E. (2000a). The amygdala and emotion: a view through fear. In: Aggleton, J.P. (Ed.), *The Amygdala: a Functional Analysis* (pp. 289-310). Oxford, England: Oxford University Press

LeDoux, J. E. (2000b). Emotion circuits in the brain. *Annual Review of Neuroscience, 23*(1), 155–184. doi: 10.1146/annurev.neuro.23.1.155

Lemercier, A., Guillot, G., Courcoux, P., Garrel, C., Baccino, B., Schlich, P. (2014). Pupillometry of taste: Methodological guide – from acquisition to data processing-and toolbox for MAT- LAB. *The Quantitative Methods for Psychology*, *10*(2), pp.179-195. doi: 10.20982/tqmp.10.2.p179

Levine, T. R. (2011). Statistical conclusions validity basics: Probability and how type 1 and type 2 errors obscure the interpretation of findings in communication research literatures. *Communication Research Reports, 28*(1), 115-119. doi: 10.1080/08824096.2011.541369

Libby, W. L., Lacey, B. C., & Lacey, J. I. (1973). Pupillary and cardiac activity during visual attention. *Psychophysiology*, *10*(3), 270–294. doi: 10.1111/j.1469-8986.1973.tb00526.x

Lillard, A. S., & Peterson, J. (2011). The immediate impact of different types of television on young children's executive function. *Pediatrics*, *128*(4), 644–649. doi: 10.1542/peds.2010-1919d

Logan, G. D. (1978). Attention in character-classification tasks: Evidence for the automaticity of component stages. *Journal of Experimental Psychology: General, 107*(1), 32-63. doi:

10.1037//0096-3445.107.1.32

Lovie, A. D. (1983). Attention and behaviourism – fact and fiction. *British Journal of Psychology, 74*(3), 301-310.

Macleod, C. M. (1991). Half a century of research on the Stroop effect: an integrative review. *Psychological Bulletin, 109*(2), 163-203. doi: 10.1037//0033-2909.109.2.163

MacLeod, C. M. (1998). Training on integrated versus separated Stroop tasks: The progression of interference and facilitation. *Memory and Cognition, 26*(2), 201-211. doi: 10.3758/bf03201133

Manceau, D., & Tissier-Desbordes, E. (2006). Are death and sex taboos in advertising? *International Journal of Advertising, 25*(1), 9-33. doi: 10.1080/02650487.2006.11072949

March, J. G. (1978). Bounded rationality, ambiguity, and the engineering of choice. *The Bell Journal of Economics, 9*(2), 587–608. doi: 10.2307/3003600

Mares, M. L., & Acosta, E. E. (2008). Be kind to three-legged dogs: Children's literal interpretations of TV's moral lessons. *Media Psychology, 11*(3), 377–399. doi: 10.1080/15213260802204355

Marks, L. E., Ben-Artzi, E., & Lakatos, S. (2003). Cross-modal interactions in auditory and visual discrimination. *International Journal of Psychophysiology, 50*(2),125-145. doi: 10.1016/S0167-8760Ž03.00129-6

Maule, A. J., & Maule, S. (2016). Aiding lay decision making using a cognitive competencies approach. *Frontiers in Psychology, 6*(1884), 1-14. doi: 10.3389/fpsyg.2015.01884

Maxwell, S. E., & Delaney, H.D. (1990). *Designing experiments and analysing data: A model comparison approach*. Pacific Grove, CA: Brooks/Cole

McCabe, D. P., Roediger, H. L., McDaniel, M. A., Balota, D. A., & Hambrick, D. Z. (2010). The relationship between working memory capacity and executive functioning: Evidence for a common executive attention construct. *Neuropsychology, 24*(2), 222-243. doi: 10.1037/a0017619

McCown, D., & Arnoult, M. D. (1981). Interference produced by modified Stroop stimuli. *Bulletin of the Psychonomic Society, 17*(1), 5-7. doi: 10.3758/bf03333649

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81-97. doi: 10.1037/h0043158

Murphy, P. R., Vandekerchove, J., & Nieuwenhuis, S. (2014). Pupil-linked arousal determines variability in perceptual decision making. *PLoS Computational Biology, 10*(9),1-13. doi: 10.5061/dryad.tb542

Murray, N. P., Hunfalvay, M., & Bolte, T. (2017). The reliability, validity, and normative data of interpupillary distance and pupil diameter using eye-tracking technology. *Translational Visual Science and Technology, 6*(4), 1-12. doi: 10.1167/tvst.6.4.2

Nayeem, T., & Casidy, R. (2015). Australian consumers' decision-making styles for everyday products. *Australian Marketing Journal, 23*(1), 67-74. doi: 10.1016/j.ausmj.2015.01.001

Obstfeld, H., & Chou, R. (1998). A study of the accuracy of corneal reflection pupillometers. *Ophthalmic and Physiological Optics, 18*(6), 527–531. doi: 10.1046/j.1475-1313.1998.00392.x

Ooms, K., Coltekin, A., De Maeyer, P., Dupont, L., Fabrikant, S., Incoul, A., Kuhn, M., Slabbinck, H., Vansteenkiste, P., Van der Haegen, L. (2015). Combining user logging with eye tracking for interactive and dynamic applications. *Behaviour Research Methods, 47(*4) 977-993. doi: 10.3758/s13428-014-0542-3

Orquin, J. L., & Loose, S. M. (2013). Attention and choice: A review on eye movements in decision making. *Acta Psychologica, 144*(1),190-206. doi: 10.1016/j.actpsy.2013.06.003.

Pallant, J. (2013). *SPSS survival manual : A step by step guide to data analysis using SPSS*(5th ed.). Maidenhead : Open University Press/McGraw-Hill

Parkes, A., Wight, D., Hunt, K., Henderson, M., & Sargent, J. (2013). Are sexual media exposure, parental restrictions on media use and co-viewing TV and DVDs with parents and friends associated with teenagers' early sexual behaviour? *Journal of Adolescence, 36*(6), 1121-1133. doi: 10.1016/j.adolescence.2013.08.019

Parmentier, F. B. R. (2014). The cognitive determinants of behavioural distraction by deviant auditory stimuli: A review. *Psychological Research, 78*(3), 321-338. doi: 10.1007/s00426-013-0534-4

Parsons, T. D., Courtney, C. G., & Dawson, M. E. (2013). Virtual reality Stroop task for assessment of supervisory attentional processing. *Journal of Clinical and Experimental Neuropsychology*, *35*(8), 812-826. doi: 10.1080/13803395.2013.824556

Pashler, H. E. (1998). *The psychology of attention.* Cambridge, MA: MIT Press Rey, G. D.

Passer, M., Smith, R., Holt, N., Bremmer, A., Sutherland, E., & Vliek, M. (2009). *Psychology: The science of mind and behaviour.* Berkshire, England: MacGraw-Hill Education

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1988). Adaptive strategy selection in decision making. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14*(3), 534–552. doi: 10.1037//0278-7393.14.3.534

Penner, I., Kobel, M., Stöcklin, M., Weber, P., Opwis, K., & Calabrese, P. (2012). The Stroop task: Comparison between the original paradigm and computerized versions in children and adults. The Clinical Neuropsychologist, 26(7), 1142-1153. doi: 10.1080/13854046.2012.713513

Peretti, P. O. (1971). Effects of non-competitive, competitive instructions, and sex on performance in a color-word interference task. *Journal of Psychology, 79*(1), 67-70. doi: 10.1080/00223980.1971.9923768

Peterson, J. A., Kushwaha, T., & Kumar, V. (2015). Marketing communication strategies and consumer financial decision making: The role of national culture. *Journal of Marketing, 79*(1), 44-63. doi: 10.1509/jm.13.0479

Pfaff, D.W., Martin, E.M., Faber, D. (2012). Origins of arousal: roles for medullary reticular neurons. *Trends in Neurosciences 35*(8), 468–476. doi: 10.1016/j.tins.2012.04.008

Piquado, T., Isaacowitz, D., & Wingfield, A. (2010). Pupillometry as a measure of cognitive effort in younger and older adults. *Psychophysiology*, *47*(3), 560-569. doi: 10.1111/j.1469-8986.2009.00947

Porter, G., Troscianko, T., & Gilchrist, I. D. (2007). Effort during visual search and counting: Insights from pupillometry. *Quarterly Journal of Experimental Psychology*, *60*, 211–229. doi: 10.1080/17470210600673818

R Core Team. (2018). R: *A Language and Environment for Statistical Computing*. Vienna, Austria: the R Foundation for Statistical Computing. Retrieved from https://www.R-project.org

Ratcliff, R., & Smith, P. L. (2004). A comparison of sequential sampling models for two-choice reaction time. Psychological Review, 111(2), 333-367. doi: 10.1037/0033-295x.111.2.333

Regan, J. E. (1978). Involuntary automatic processing in color-naming tasks. *Perception and Psychophysics, 24*(2),130-136. doi: 10.3758/bf03199539

Rey, G. D. (2012). A review of research and a meta-analysis of the seductive detail effect. *Educational Research Review, 7*(3), 216-237. doi: 10.1016/j.edurev.2012.05.003

Rieger, G., & Savin-Williams, R. C. (2012). The eyes have it: Sex and sexual orientation differences in pupil dilation patterns. *PLos ONE, 7*(8),1-10. doi: 10.1371/journal.pone.0040256.

Salkind, N. J. (2009). *Exploring research.* Upper Saddle River, NJ: Pearson Education

Santos, J. E, & Montgomery, J. R. (1962). Stability of performance on the color-word test. *Perceptual and Motor Skills, 15*(2), 397-398. doi: 10.2466/pms.1962.15.2.397

Schafe, G.E., LeDoux, E.J. (2004). The neural basis of fear. In: Gazzaniga, M.S. (Ed.), *The Cognitive Neurosciences* III (pp. 987-1004). Cambridge, MA: The MIT Press

Schubo, W., & Hentschel, U. (1977). Reliability and validity of the serial Color-Word Test: Further results. *Psychological Research Bulletin, Lund University, 17*(6), 5169.

Schubo, W., & Hentschel, U. (1978). Improved reliability estimates for the serial Color-Word Test. *Scandinavian Journal of Psychology, 19*(1), 91-95. doi: 10.1111/j.1467-9450.1978.tb00307.x

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston: Houghton Mifflin.

Shichel, I. & Tzelgov, J. (2017). Modulation of conflicts in the Stroop effect. *Acta Psychologica.* doi: 10.1016/j.actpsy.2017.10.007

Shiv, B., & Fedorikhin, A. (2002). Heart and mind in conflict: The interplay of affect and cognition in consumer decision making. *Journal of Consumer Research, 26*(3), 278–292. doi: 10.1086/209563

Simon, H. A. (1955). A behavioral model of rational choice. Quarterly Journal of Economics, 69(1), 99–118. doi: 10.2307/1884852

Simon, H. A. (1957). Models of man; social and rational. Oxford, England: Wiley.

Smith, G. J. W., & Nyman, G. E. (1974). The validity of the serial color-word test: A reply to Lennart Sjöberg. Scandinavian Journal of Psychology, 15(1), 238-240. doi: 10.1111/j.1467-9450.1974.tb00582.x

Stocco, A., & Fum, D. (2008). Implicit emotional biases in decision making: The case of the Iowa Gambling Task. Brain and Cognition, 66(3), 253–259. doi: 10.1016/j.bandc.2007.09.002

Strauss, G. P., Allen, D. N., Jorgensen, M. L., & Cramer, S. L. (2005). Test–retest reliability of standard and emotional Stroop tasks. *Assessment, 12*(3), 330-337. doi: 10.1177/1073191105276375

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18*, 643-662.

Swami, S. (2013). Executive functions and decision making: A managerial review. *IIMB Management Review, 25*(4), 203-212. doi: 10.1016/j.iimb.2013.07.005

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*(2), 257-285. doi: 10.1207/s15516709cog1202_4

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*(4), 295-312. doi:10.1016/0959-4752(94)90003-5.

Sweller, J. (2010). Element interactivity and intrinsic, extraneous and germane cognitive load. *Educational Psychology Review, 22*(2), 123-138. doi: 10.1007/s10648-010-9128-5.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*(3), 185-233. doi: doi.org/10.1207/s1532690xci1203_1

Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive load theory*. New York: Springer

Sweller, J., Van Merriënboer, J. J. G., & Paas, F. G. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251-296. doi:10.1023/A:1022193728205.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston: Pearson Education

Tønnessen, E., Haugen, T., & Shalfawi, S. A. (2013). Reaction time aspects of elite sprinters in athletic world championships. *The Journal of Strength & Conditioning Research, 27*(4), 885-892. doi: 10.1519/jsc.0b013e31826520c3

Trochim, W. M. K. (2006). *Research methods knowledge base.* Retrieved from https://socialresearchmethods.net/kb/index.php

Tromp, J., Hagoort, P., & Meyer, A. S. (2018). Pupillometry reveals increased pupil size during indirect request comprehension. *The Quarterly Journal of Experimental Psychology, 69*(6), 1093-1108. doi: doi.org/10.1080/17470218.2015.1065282

Uechi, Y. (1972). Cognitive interference and intelligence: Re-examination of the measures of SCWT. *Japanese Journal of Educational Psychology, 20*(2), 92-100. doi: 10.5926/jjep1953.20.2_92

Van Dillen, L. F., Hoffman, W., & Papies, E. K. (2013). Turning a blind eye to temptation: How cognitive load can facilitate self-regulation. *Journal of Personality and Social Psychology, 104*(3), 427-433. doi: 10.1037/a0031262

Van Merriënboer, J. J. G., & Ayres, A. (2005). Research on cognitive load theory and its design implications for E-learning. *Educational Technology, Research and Development, 53*(5), 5-13. doi: 10.1007/BF02504793

Van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review, 17*(2), 147–177. doi: 10.1007/s10648-005-3951-0

Van Merriënboer, J. J. G., Kester, L., & Paas, F. (2006). Teaching complex rather than simple tasks: Balancing intrinsic and germane load to enhance transfer of learning. *Applied Cognition Psychology, 20*(3), 343-352. doi: 10.1002/acp.1250

Wachler, B. S. B., & Krueger, M. D. (1999). Agreement and repeatability of infrared pupillometry and the comparison method. Ophthalmology, 106(2), 319–323. doi: 10.1016/s0161-6420(99)90070-2

Wang, Y., & Ruhe, G. (2007). The cognitive process of decision making. *International Journal of Cognitive Informatics and Natural Intelligence, 1*(2), 73-85.

Wang, Y., Wang, Y., Patel, S., & Patel, D. (2004). A layered reference model of the brain (LRMB). *IEEE Transactions on Systems, Man, and Cybernetics ©, 36*(2), 124-133.

Ward. L. M. (2003). Understanding the role of entertainment media in the sexual socialization of American youth: A review of empirical research. *Developmental Review, 23,* 347-388. doi: 10.1016/S0273-2297(03)00013-3

Wartella, E., Beaudoin-Ryan, L., Blackwell, C. K., Drew, P., Cingel, D. P., Hurwitz, L. B., & Lauricella, A. R. (2016). What kind of adults will our children become? The impact of growing up in a media-saturated world. *Journal of Children and Media*, *10*(1), 13-20. doi: 10.1080/17482798.2015.1124796

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. New York: Springer-Verlag

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological bulletin*, *120*(1), 3-24. doi: 10.1037//0033-2909.120.1.3

Willig, C. (2009). *Introducing qualitative research in psychology* (2nd ed.). Buckingham, England: Open University Press.

Wilson, R. A., & Keil, F. C. (2001). *The MIT Encyclopaedia of the Cognitive Sciences.* Cambridge, MA: MIT Press

Woodman, G. F., Vogel, E. K., & Luck, S. J. (2001). Visual search remains efficient when visual working memory is full. *Psychological Science*, *12*(3), 219-224. doi: 10.1111/1467-9280.00339.

Yantis, S., & Johnston, J. C. (1990). On the locus of visual selection: Evidence from focused attention tasks. *Journal of Experimental Psychology: Human Perception and Performance, 16*(1), 135-149. doi: 10.1037//0096-1523.16.1.135

Yoder, C. Y., Weitzen, S., Williams-Pickle, L., Grant, B., Herrmann, D., & Schnitzer, S. B. (2010). Cognitive functioning in the last year of life as a function of age, gender, and race. *Experimental Aging Research*, *27*(3), 241-256. doi: 10.1080/036107301300208682

Zajano, M. J., Hoyceanyls, E. M., & Ouellette, J. F. (1981). A confound in the standard control condition of the Stroop experiment. *Perceptual and Motor Skills, 53*(3), 835-841. doi: 10.2466/pms.1981.53.3.835

Zsambok, C. E. (1997). Naturalistic decision making: Where are we now? In C.E. Zsambok & G. Klein (Eds.), *Naturalistic decision making* (pp. 316). Mahwah, NJ: Erlbaum.

Zsambok, C. E., & Klein, G. (1997). *Naturalistic decision making*. Mahwah, NJ: Erlbaum

Appendix A: Emotional arousal stimuli

Low Arousal	Mild arousal	High arousal
Unit	Vomit	Fuck
Corridor	Warmth	Asshole
Computer	Suicide	Scrotum
Kettle	Peace	Dick
Barrel	Torture	Piss
Bowl	Affection	Cock
Lawn	Loneliness	Whore
machine	Enjoyment	Bitch
Field	Laughter	Shit
Inhabitant	Discomfort	Pussy
Alley	Miracle	Slapper
Spray	Hostage	Prick
Cottage	Poverty	Slut
	Comfort	Crap
	Kiss	Cunt
	Debt	

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Appendix B: Participant recruitment form

CALL FOR STUDENTS AS RESEARCH PARTICIPANTS

STUDY: The main aim of this study is to determine whether emotional stimuli and cognitive load have an impact on everyday decision-making. All students between the ages of 18 and 28 years who are registered for any module at the University of Pretoria are invited to participate in the study.

OVERVIEW OF AND INFORMATION ABOUT THE STUDY

The purpose of the study
The researcher, a Masters Research Psychology student at the University of Pretoria, is conducting a study which attempts to explore the impact of emotional arousal and cognitive load on decision-making.

Participation
Individuals who choose to participate in the study will be agreeing to complete a short computerized survey where demographical information will be collected and the ability to work on a computer will be confirmed. In addition to the survey, the participant will be required to complete a short task where response times will be recorded using a laptop and a non-evasive eye tracker that is mounted onto the laptop. This will be completed on a laptop during a time that is agreed upon by you as the participant and the researcher. The total administration time of the experiment is approximately 15 minutes. If you are interested in participating, please contact the researcher via email or SMS (contact details below).

The researcher will assure confidentiality of your personal information as well as assessment results. No identifiable information will be collected. Participants will be assigned a numerical code identifier to ensure this confidentiality. Since your participation in the study is voluntary, you may withdraw from the study at any point in time without offering an explanation and without any consequences to you. There are no foreseeable or anticipated risks by participating in this study.

The researcher will be present and willing to assist you during the time that you undertake the assessment. Any further questions regarding the research study may be directed to the principal researcher. Your voluntary participation will be greatly appreciated.

Regards,
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Appendix C: Information sheet and informed consent form

STUDY: The influence of emotional stimuli and cognitive load on decision-making capacity

There are two parts to this informed consent form:

- An information sheet (provides information about the study)
- A consent form (sign if you choose to participate)

You will receive a copy of the information sheet.

Part 1: Information sheet

The purpose of the study

The researcher, affiliated with The University of Pretoria, is conducting a study aimed at investigating the impact of emotional stimuli and different levels of cognitive load on decision-making. What we will be looking at is how, if at all, cognitive processing differs when exposed to different intensities of emotional words as well as easier and more difficult word items when an individual is required to make a decision.

Participation

Should individuals agree to take part in the study, each individual participant will be agreeing to a basic colour-blindness test which is non-evasive. They will be agreeing to participate in a short experiment which will take part on a computer completing a basic colour naming task. Please take note that at times explicit words, like swear words and words with sexual connotations, will be displayed on the screen. If you feel at any time uncomfortable and do not want to continue, please inform the researcher immediately who will terminate the session and debrief you. Psychological services will also be made available to you.

Eye Tracker: For the purposes of the experiment, you will need to work on a laptop with an eye-tracker mounted onto it at the bottom of the screen. This device will closely monitor your eye-movements. This device will cause you no harm in any way and will not damage your eye. It has been tested in many countries around the world and found to be safe. Please note that the device holds a camera which will record your eye-movements and all actions made on the computer will also be recorded.

Participation in the study and all the results will be kept confidential. The researcher will assist you if you have any questions throughout the experiment. There will be no information that will connect you personally to the study. No identifiable information will be collected. All the data collected from your participation will be stored in safe place behind lock and key, and password where necessary. Only the researchers will have access to the data. The information gathered during the course of the research process will only be used for the purpose of the research study and will thereafter be stored in a safe location at the University of Pretoria for 15 years for archiving purposes. If you wish to remain informed on the results of the study, you may contact the principal researcher for further information (contact details provided below).

Your participation in this study is voluntary, which means that you may withdraw at any time without having to offer an explanation and without any consequences to you. If you experience any discomfort during the course of the experiment please notify the researcher and assistance will be provided where necessary.

If some of the words or concepts contained within this document are not familiar to you, or if you do not understand some or any of the information provided, please inform the researcher of this so that they may provide a clearer explanation.

Any further questions regarding the research study may be directed to the principal investigator:

Rochelle Floudiotis (Rochelle_kirstein@hotmail.com)

RESEARCH STUDY: The influence of emotional stimuli and cognitive load on decision-making capacity

Part 2: Consent to participate

I hereby confirm that I have been informed about the nature and procedures, of the study. I also give permission for the eye-tracker to be mounted at the bottom of the laptop screen and for my eye-movements to be recorded, as explained in the information sheet. I am aware that the information will only be used for research purposes now and in the future, and that my confidentiality will be protected. I am also aware that some words presented are explicit. I agree to voluntarily participate in the study and I am aware that I can withdraw at any time without offering any explanation or suffering any consequences.

Participant signature ________________________

Date ________________________

Researcher signature ________________________

Date ________________________

Thank you for your participation!

Appendix D: Experimental procedure instructions

Informed consent. In front of you is an information sheet and an informed consent form, we will go through both together. The information sheet, part one, is for your perusal and gives you a little more detail about what my study is about and what instruments I will be using throughout the study. Part two is the informed consent form. By signing this form you give me permission to include you in the data collection and also state that you participate voluntarily and are aware of what the study involves. I am going to give you some time now to read through both parts of the form. If you have any questions, please do not hesitate to ask me. Once you've read through the form and are ready to participate, please sign there (show on the form). Before you sign anything though, I just want to make sure you do know that there will be some explicit swear words as well as words that are deemed vulgar in the experiment. If you are not comfortable with that now or any time throughout the experiment, please let me know. I will terminate the session immediately.

Here is a copy of the information sheet just in case you want to read through it later, my contact details are also on there.

Orientation to experimental setup. Let me explain what is in front of you. You have the laptop that we will be using throughout the entire experiment and at the bottom of the screen is the eye tracker. It will record all eye movements from beginning to end. What's important from your side is to keep your eyes on the screen at all times, especially during the actual task. Also, once you've been positioned, please try to not move the chair back or forward or adjust your posture too much. Do you have any questions thus far?

Participant information and calibration of eye tracker. Right then let's get started. I am first going to ask you to fill in demographic information. This is called the calibration screen and it is where the eye tracker gives you a small task and all you have to do is follow the dot on the screen with your eyes. The reason for this is to make sure that the eye tracker has detected your eyes and has registered their movement. When you are ready to begin, press the right arrow key and then just focus on the screen.

Impairment control. Now if you could please read the instructions and complete the questions. What will happen now is that a picture will appear every 3 seconds on the screen. There may or may not be a number on the screen. Your job is to either identify t hat number and tell me what it is immediately, or to say that there is no number at all on the screen. This is just to make sure that you can complete the actual task a little later.

Stroop practise. “Please listen to the researcher for further instructions”: What will follow now are a few practice examples of what the actual task, called the Stroop task, will look like. As you can see, there are four colour-marked keys on the screen. A is RED, D is GREEN, J is BLUE and L is BLACK. Your job is to identify the colour of the ink of the word on the screen and then press that corresponding colour key. For the practise round, the words are on the screen for 3 seconds. Try your best and be as quick as possible, but accuracy is also important. Do you have any questions? When you are ready please press the space bar.

Final Stroop instructions. You have now completed the practise trials and the next task is the actual Stroop task. Before you begin, do you have any questions? Please ask now because once the experiment starts I won’t be able to answer anything. The experiment is the same as the practise rounds but the words will now appear and disappear faster, so please try respond as quickly and accurately as possible. I’m just going to sit here to make sure there are no technical issues, is that okay? Are there any final questions? Have a final read through the instructions and when you are ready, you may start.

Debriefing. How was that? What theory tells us is that when one is exposed to arousing words (like swear words) or tasked with a difficult decision (where the word red was printed in blue ink), then the pupil dilates more because the mind is doing more work than usual. As a result, making a response should have been slowest during the easier trials and fastest during the most difficult trials. This is what happened during the experiment: the eye tracker measured each of your pupil’s diameters at a rate of 60Hz, which means that 60 frames were captured every second. And that’s it.

Conclusion. Do you have any questions? Do you feel like you would like to go talk to someone about the words that you were exposed to or how the experiment made you feel?

Thank you for agreeing to participate, have a good day.