Time flies when you're having fun: Investigating the influence of positive emotions and cognitive load on time perception in the retrospective paradigm

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Abstract

The literature predicts a paradoxical effect on time perception under the influence of positive emotion and high cognitive load in the retrospective paradigm. High cognitive load is expected to increase time perception, whereas positive emotion is expected to decrease time perception. A quasi-experimental within-subjects design was devised that manipulated emotion on two levels (positive and neutral) as well as cognitive load on two levels (high and low) to investigate the effect on time perception. The findings of the study prove disappointing with no main effects witnessed along any of the four experimental conditions. Participants overestimated all the durations, but under the high cognitive load, positive emotion condition, the mean time perception scores where the closest to the chronological time.

Key-words: time perception, retrospective paradigm, emotion, cognitive load

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The present research investigates the effect of positive emotion and cognitive load on time perception in the retrospective paradigm. In order to do this, the researcher devised an experiment with four experimental conditions manipulating two levels of the two independent variables under investigation and one control condition. This includes a difficult and an easy reading task, a difficult and an easy game task and the empty interval control task. The difficult game task is of particular interest as this is the task that is the positive emotion, high cognitive load experimental condition.

Chapter 1: Introduction

This chapter explores the research problem and the the motivation for the present research. The aim and objectives of the study will be discussed and an overview of the methodology and theoretical paradigm of the present research will also be presented. This chapter serves as an introduction and overview of the complete report and concludes with a discussion on the structure of the report.

Context of research problem

Time perception research is a booming field of study in both psychology and neuroscience (Hancock & Block, 2012). However, results from time perception studies are sometimes contradictory and our theoretical understanding of how time perception is influenced and by which factors it is influenced is compromised (Eagleman, 2008). Evidence from neuroscience with the use of functional magnetic resonance imaging (fMRI) has demonstrated that several areas of the brain are active during timing tasks. The activated areas are related to cognitive processes like attention, working memory and decision-making, which is indicative of the complexity of the neural networks related to time perception (Wittmann, 2009). The complexity of to the number of areas active during time perception implies that a breakdown at any point in the system will lead to a failure of the entire system: Hence, impaired time perception.

Consequently, it stands to reason that teasing apart individual influences on time perception is a monumental task. This task is made more difficult when one takes contradictory findings and competing theoretical explanations into account as well. Contradictory findings can probably be explained by two nuanced aspects of time perception research. Firstly, time perception studies are conducted within one of two paradigms that tap into different cognitive and neurological structures (Grondin, 2010). Secondly, a great variety of factors both internal and external to participants influence time perception (Le Poidevin, 2009).

The two paradigms of time perception research are the retrospective and prospective paradigms. These paradigms are discussed in more detail in subsequent sections of this report, however, a simplified distinction can be drawn between the two paradigms based on participants' prior knowledge that they will be asked to estimate a duration or not (Grondin, 2010). In the retrospective paradigm participants are not told that they will be required to estimate the duration that has passed. In the prospective paradigm participants are told in advance that a duration judgement will be required.

The retrospective paradigm relies more on participants' working memory capacity whereas the prospective paradigm relies more on attentional factors (Brown, 2008). This distinction might not seem important, but researchers have demonstrated that for some factors that influence time perception the paradigm of the research influences the results of the research. For example Khan, Sharma and Dixit (2006) found that cognitive load affects time perception differently in the two paradigms. They found that the strength of the relationship between cognitive load and time perception was significantly greater in the prospective paradigm when compared to that of the retrospective paradigm. Brown (2010) compared the same task with two levels of difficulty from both paradigms and found that duration judgements in the retrospective paradigm tended to be more variable. This was attributed to the differing role attention plays in the two paradigms. As attention in the retrospective paradigm is not directed towards timing, duration judgements seem to be influenced in that they sometimes become longer but generally become more varied and unreliable.

Attention is one of the factors that influence time perception (Brown, 2008). Other factors include but are not limited to emotions (Droit-Volet & Gil, 2009), arousal (Droit-Volet & Meck, 2007), cognitive load (Block, Hancock, & Zakay, 2010), depth of processing (Arlin, 1986), amount of information processed (Hicks, Miller, & Kinsbourne, 1976), age and cognitive development (Zélanti & Droit-Volet, 2011), gender (Hancock & Rausch, 2010), listening to or hearing music (Droit-Volet et al., 2010), and neurobiological factors (Lalonde & Hannequin, 1999). Most of these factors will be discussed in detail in the literature review of this report.

Investigating all the factors that influence time perception is practically impossible, especially considering that new research is constantly identifying new and complex ways in which time perception is influenced (Hancock & Block, 2012). Adding to this the complication of the two paradigms, one can see that studying time perception is a complex and nuanced task. Two factors that influence time perception are particularly interesting to the researcher: Emotions and cognitive load.

Research suggests that emotion and time perception is strongly linked (Droit-Volet & Gil, 2009). Time seems to fly by when we are having fun, but drags by when we are bored (Droit-Volet & Meck, 2007; Wittman, 2009). Evidence to support the adage *time flies when you're having fun,* has been found in time perception literature regardless of the paradigmatic point of departure of the study. Some, like Brown (2008; 2010), explain such findings in terms of the role attention plays in time perception. Brown (2008; 2010) argues that when participants are having fun, attention is directed away from time leading to shorter duration judgements.

The opposite is true of boring activities, but no explanation is given as to the role negative emotions play in influencing time perception. This point is not explored in detail in the present research, but could provide a future avenue for research.

Contrary to this, cognitive load's influence on time perception has a paradoxical effect depending on the paradigm (Khan et al., 2006). In the retrospective paradigm, attention is focused on the primary task (and consequently directed away from the passing of time), which leads to longer duration estimates under high cognitive load conditions (Block et al., 2010). The opposite is true for the prospective paradigm where attention is divided between the primary task and the secondary task of estimating the time that is passing (Brown, 2008).

In the retrospective paradigm of time perception research, duration judgements increase as cognitive load increases (i.e. a positive correlation exists between duration judgement and cognitive load). However, as positive emotions increase, duration judgements tend to decrease (i.e. a negative correlation exists between duration judgements and positive emotions.) Thus, what happens to duration judgements when cognitive load and positive emotions increase? As such, the proposed study will endeavour to investigate the influence of positive emotions and cognitive load on time perception in the retrospective paradigm.

Motivation for research

The present study is justified in that it will contribute to the theoretical understanding of the interaction of positive emotion and cognitive load on time perception in the retrospective paradigm. Researching the impact of this particular combination of independent variables on the dependent variable in the retrospective paradigm is unique to the present research. Evidence support the existence of a link between emotion and time perception (Droit-Volet & Meck, 2007; Droit-Volet et al., 2011; Grondin, 2010) and between cognitive load and time perception (Brown, 2008; Eagleman, 2008; Ivry & Schlerf, 2008), however, little or no research has been done on the combined influence of emotion and cognitive load on time perception (Block & Gruber, 2014).

Research on the link between emotion and time perception in the range of minutes and conducted in the retrospective paradigm is quite limited, according to a meta-analytic review of time perception literature by Grondin (2010). The present research will contribute to this limited body of knowledge by investigating the influence of positive emotion on time perception for somewhat longer durations in the range of minutes.

Aim of study

The aim of the present research is to further theoretical knowledge in the field of time perception. Specifically, the present research aims to further theoretical knowledge regarding the combined effect of emotion and cognitive load on time perception in the retrospective paradigm. The effect has been extensively researched in the prospective paradigm, but gaps in the literature reveal a need to understand this effect in the retrospective paradigm as it relates to memory systems.

Objectives of study

The objectives of the present research are to manipulate participants' emotional state as well as cognitive load and to investigate the effect of these manipulations on time perception. The present research will use a laboratory setting and quasi-experimental design to achieve the objective of manipulating the independent variables in a safe and controlled way. In addition, the objective is to compare the effect of the independent variables on time perception to that of a control condition where both emotional states and cognitive load are neutral and low.

Overview of methodology of study

The current research study has a quantitative, quasi-experimental, within-subjects design (Shadish, Cook, & Campbell, 2001; Gravetter & Forzano, 2009). A non-randomized quota sampling method is used to obtain a sample that is balanced for gender as far as is possible (Gravetter & Forzano, 2009). Similarly, participants are required to be in an age cohort and similar levels of academic and reading proficiency are required as these can all be potentially confounding to the present research.

The present research uses two measurement instruments including a portable infrared eye tracker and self-report questionnaire. The experiment consists of five conditions. The conditions are designed to manipulate cognitive load along two levels (high and low), and emotion along two levels (positive and neutral) with four experimental tasks. The fifth task is a control task comprising an empty interval. All participants are required to complete all five tasks. The self-report questionnaire is administered by the researcher at the end of each task so participants can rate how much fun they had (positive emotion) and how difficult the task was (cognitive load). Other manipulation checks and distracter questions are also posed. After the final task, participants are asked to estimate each of the tasks for the length of the task. The eye tracker is fixed to participants' heads at the start of the experiment and they wear the device for all five tasks. The purpose of the eye tracker is to provide a physiological measure of cognitive load to augment data from the self-report questionnaire.

Overview of theoretical paradigm of study

As mentioned previously, there are two theoretical paradigms in time perception research. The distinction between these paradigms is made based on prior knowledge that a duration judgement will be required. In the prospective paradigm, participants are told beforehand that time perception is the goal of the study and as such, participants are aware that a duration judgement will be required (Grondin, 2010). In contrast to this, participants in the retrospective paradigm are unaware that time perception will be measured. After completing a task, participants are required to provide a duration judgement based on their memory of the elapsed target duration (Block & Zakay, 1997). The present study is conducted from the retrospective paradigm. Both paradigms will be discussed in greater depth in the following chapter as part of the literature review.

Structure of report

The report comprises an introductory chapter that gives the reader a broad overview of the present research including methodology and theoretical paradigm. The second chapter is the literature review. The literature review discusses in greater depth the finer nuances of the present research based on peer-reviewed academic research. Chapter two of the dissertation also provides the reader with a better understanding of the scope of the research problem addressed in the present research.

The third chapter explains the complete methodology of the research as well as the threats to validity. The methodology chapter is a systematic recording of the processes followed by the researcher while conducting the present research. The chapter also explains the reasoning behind the researcher's methodology based on literature on research methodology in the social sciences.

The methodology chapter is followed by a chapter on the statistical analysis of the data gathered during the present research. Chapter four will report the results of the present research based on a thorough statistical analysis of participant scores. The fifth chapter provides a discussion of the findings where the results and literature are married to draw inferences from the research. Chapter six presents the limitations of the study along with the researcher's conclusion of the present research. The final chapter also explains the researcher's acceptance of either the research or the null hypothesis.

This chapter is followed by a complete reference list and several appendices with additional information. Information contained in the appendices include sample self-report questionnaires, sample reading texts and other information the researcher deems relevant as supplementary to the report.

Chapter 2: Literature review

Do we have a sense to perceive time? The answer to this question is both simple and complex: We do not have one specific sense to perceive time, yet we are still able to perceive it (Wittman, 2009). The complexity of the phenomenon of time perception is deliberated in philosophy (Le Poidevin, 2009), science (Brown, 2008; Eagleman, 2008; Grondin, 2010) and popular culture (Alter, 2010; Venton, 2011), however, defining time perception is no small feat.

An important distinction is drawn between objective or clock-time, and subjective or psychological time (Block et al., 2010; Grondin, 2010). Psychological time is vulnerable to manipulation by internal factors (Droit-Volet, Fayoll, & Gil, 2011). These factors influence our experience of the amount of time that has passed or what is termed time perception.

The literature review commences with an overview of several notable models of time perception. These include the internal clock and the attentional-gate model. The role of attention and memory in time perception is also addressed because these are some of the distinguishing factors between the models of time perception. Thereafter, the discussion turns to specific variables that influence time perception. The variables most pertinent to the present study are discussed in the most detail, linking them to time perception specifically. These variables include cognitive load, emotion and time perception. Furthermore, a review of possible moderating variables is given and discussed at length. The chapter concludes with a discussion on the threats to the validity of the present research and the researcher's efforts to protect against the threats.

Theoretical paradigm of study

As mentioned in the first chapter, there are two prominent paradigms of time perception research: retrospective and prospective timing. The present study is conducted from the retrospective paradigm, however, an overview of both paradigms is discussed here with the purpose of illuminating differences between the two paradigmatic points of departure.

Time perception research done within the prospective paradigm consists of participants being told beforehand that they will be asked to estimate the time that has elapsed (Droit-Volet & Meck, 2007; Grondin, 2010). Often, such research consists of estimations made of elapsed seconds or milliseconds. In other words, participants are warned beforehand that they will be required to judge the duration of time passed while they were busy with another task. Participants are consequently required to divide their attention between the primary or experimental task and the secondary task of estimating the amount of time that they have experienced while completing the task. As a result, some theorists refer to duration estimates in the prospective paradigm as experienced duration (Tobin & Grondin, 2009). This is not to say that all prospective paradigm research employ a dual-task method – where participants are given a distractor task to complete while timing – but that the task of timing is made explicit and the interval to be estimated is clearly marked by any number of ways.

The retrospective paradigm in time perception research refers to psychological duration judgments made without warning that such judgments will be required (Droit-Volet & Meck, 2007). Normally, research done from the retrospective paradigm focuses on greater durations like minutes or hours as opposed to seconds or sub-seconds, however, this might not always be the case (Grondin, 2010). Retrospective studies also tend to rely on self-report, but may include reproduction or comparison tasks. Participants in the retrospective paradigm have no knowledge that they will be required to estimate the time that has passed while they were completing a particular task. As such, it can be said that participants in the retrospective paradigm only pay attention to time incidentally. Participants in the retrospective paradigm therefore base their duration judgement on their memory of the interval length. Thus, some theorists prefer to use the term remembered duration when referring to duration estimates in the retrospective paradigm (Tobin & Grondin, 2009).

Critically, a distinction is made between the two paradigms based on the role attention plays in either paradigm. Prospective timing requires on-going attentiveness to time, whereas retrospective studies rely on incidentally encoded timing information (Brown, 2008). Comparing findings from studies using the two paradigms have led to valuable insights into the role attention plays in time perception. These insights are discussed in more detail in a later section on the role of attention in time perception based on their relevance to the current research.

Some of the key findings of a meta-analytic review comparing studies in the different paradigms are the following: Firstly, prospective judgements on average tend to be longer than retrospective judgements of the same elapsed time intervals (Block & Zakay, 1997). Secondly, retrospective judgements on average tend to be more variable than prospective judgements of the same lengths of time.

The question remains whether time perception in the two paradigms involves the same or different cognitive processes. According to Brown (2010), the experience of time is undoubtedly different depending on the paradigm. For example, in the retrospective paradigm, timing is incidental and there necessarily exists a greater reliance on memory and decision-making as the elapsed duration is compared to other durations held in memory. Compare this to prospective timing where time perception is a deliberate exercise of cognitive functioning. Attention is directed toward timing and a duration estimate is made based on the perceptual experience of time.

There is, however, research that indicates that participants respond similarly to various distractor tasks during timing experiments conducted in both of the paradigms (Kurtz & Strube, 2003). Such research seems to indicate that the same processes underlie timing in both paradigms, but the degree to which these processes function during time perception differs depending on the paradigm. For example, time perception could be viewed on a continuum of attentiveness to timing (Brown & Stubbs, 1992). This is to say that in the retrospective paradigm, attentiveness is at its lowest, whereas in the prospective paradigm attentiveness is at its highest.

Block and Zakay's (1997) findings – that prospective judgements tend to be longer than retrospective judgements of the same interval length and that retrospective judgements tend to be more varied – are consistent with the idea that attention plays a greater role in research done from a prospective paradigm. Similarly, duration judgements in the retrospective paradigm are based on incomplete perceptual input as a result of the lack of attention paid to the elapsed time and as such, duration judgements are relatively shorter and less reliable. However, Block and Zakay's (1997) findings are not universal. Boltz (2005) demonstrated that retrospective judgements could become more accurate and reliable with increased exposure.

In his study, Boltz (2005) required participants to reproduce durations of between 9.1 and 11.6 seconds. Some participants were aware that a duration judgement would be required (prospective paradigm) and some participants were unaware (retrospective paradigm). The target duration was played in the form of a short video either four or eight times. As initially expected, prospective duration judgements were more accurate. Yet, retrospective judgements became similarly reliable for the group of participants who saw the video more times.

This seems to indicate that it is complex to understand the differences and similarities in the processes underlying the two paradigms. Further comparative studies could be a potential avenue for future research and help to illuminate the different cognitive structures that underlie time perception in each paradigm.

Models of time perception

Over the last few decades, cognitive and neuropsychological theories have dominated time perception research. However, with the so-called "emotive turn" (Wittmann, 2009, p. 1956), researchers in the field of time perception have started to focus on the role emotion and mood states play in time perception. Along with the focus on internal states came a lot of conflicting evidence leading to the development of several new models or variations on old models of time perception and countless new theories. The mechanisms behind time perception are also a matter of debate (Tobin & Grondin, 2009). As it stands, there seems to be a lot of conflicting evidence and competing explanations in the field (Wittmann, 2009), which are most likely attributable to both the focus on internal states like emotions and the resultant upset over the mechanisms behind timing. In this section, a brief overview of the most prominent cognitive and neuropsychological models of time perception will be presented.

Broadly speaking, these models can be subdivided into either dedicated or intrinsic models. Dedicated models purport the existence of an internal mechanism analogous to the working of a clock, dedicated to perceiving time. Intrinsic models, on the other hand, hold that there is no need to assume the existence of such a mechanism, but that time perception is inherent in the functioning of neural networks. As such, it is evident that different mechanisms seem to underlie time perception when considering dedicated and intrinsic models. Dedicated models seem to argue that biological processes underlie timing (Block et al., 2000). These biological processes or the internal clock so to speak, are influenced by biological rhythms like body temperature, digestion and circadian rhythms. This is not to say that cognition and neurobiological factors do not play a role in dedicated models of time perception, but rather that biological processes are theorized to be of greater significance.

Theorists are currently divided as to whether the same or distinct cognitive processes underlie timing in the retrospective and prospective paradigms (Block & Zakay, 1997). It is most likely true that different cognitive processes underlie timing in the various paradigms, because the same experimental conditions result in different duration estimates based on the paradigm involved. For example, the role decision-making plays in the retrospective paradigm when a remembered interval is compared to the presented interval, as opposed to the prospective paradigm where no such decision has to be made.

Lastly, dedicated and intrinsic models seem to differ in terms of the scale of intervals best explained by each grouping. Again, there seems to be some disagreement as to whether this is in fact the case, however, most theorists seem to agree that an important distinction is the one-second mark. Theorists usually distinguish between research done with sub-second and longer intervals (Block et al., 2010; Brown, 2008; Ivry & Schlerf, 2008). Sub-second durations refer to time periods that are shorter than one clock-timed second. Durations that exceed one second are termed longer durations. Studies using a dedicated model of time perception tend to work well with sub-second durations, however, few studies using an intrinsic model of time perception use sub-second target intervals. The question remains whether this is a function of the explanatory power of the various types of models, or just mere preference on the part of the researchers.

Dedicated models: internal clock. The traditional view of time perception is that a central mechanism or internal clock is responsible for humans' ability to estimate time (Grondin, 2010). There are two main lines of thought related to this model. The first is that of the pacemaker-counter, which is considered a linear process related to an information processing perspective. The second is that of the oscillator, which is considered a dynamic, non-linear system. Other theoretical positions within the internal clock model also exists, however, these are not as prominent. For example, Staddon and Higa (1996, 1999) proposed a cascade of interval timers where the decay in memory strength determines the experience of intervals and time perception. Wackermann and Ehm (2006) proposed the dual-clepsydra model, which states that time is accumulated via inflow and outflow systems. This model applies best to reproduction tasks. In such tasks, participants have to recreate durations presented to them by, for example, tapping their fingers on a table to indicate the start and end of the interval.

The pacemaker-counter model is the dominant view of internal clock models. The model looks as follows: The pacemaker sends out pulses that the counter stores. The number of pulses the counter stores determines the perceived length of the interval (Grondin, 2010). Scalar expectancy theory (SET) is the most prominent theory based on the pacemaker-counter model in prospective time perception studies (Block et al., 2010). SET theorises animal timing behaviour based on Weber's Law (Gibbon, 1977). Weber's Law (also termed the Weber-Fechner Law) states that the change in a stimulus that is just noticeable occurs at a constant ratio of the original stimulus: $\Delta I \div I = K$. That is to say you will not easily perceive a difference between intervals of 1s and 1.01s because the just noticeable difference is 0.1s – in other words, the difference needs to be greater than 0.1s to be easily perceptible. Weber's Law is commonly accepted in psychophysics and perception research despite it being disproven for stimulus extremes.

According to other theories based on the pacemaker-counter model, time perception differs because four possible errors can occur. Pacemaker error occurs when the pacemaker sends out pulses in an irregular fashion. Counter error occurs when the counter 'drops' pulses or misses count. As objective time intervals increase, the error in judgment can increase exponentially (Grondin, 2010). In other words, a person is not likely to mistake a second for a minute, but one might mistake five minutes for six.

The third error related to the pacemaker-counter model is associated with attention mechanisms. Switch and marking error proposes that attention is a kind of switch that can be turned on and off. When the switch is on, full attention is dedicated to time, resulting in longer duration judgements. This is because when the switch is on, the counter stores more pulses. In order for the switch to be turned on or off, the interval needs to be marked for its beginning and end. The error that occurs is a result of the latency between the objective and subjective signals delineating the interval that needs to be judged (Grondin, 2010).

The fourth and final error related to the pacemaker-counter model is connected to memory and decision-making. Memory and decision error purports the presence of an interval constant that is normally distributed. When performing a task, the duration of that task is compared to the constant as either longer or shorter (Grondin, 2010). This comparison is based on memory of the constant and involves a decision-making process, in other words, is the current duration longer or shorter than the interval held in memory? The error best explains bisection tasks where participants have to switch estimates from a series of short intervals to a series of long intervals and some spill-over occurs.

The second main line of thinking of dedicated models of time perception is the oscillator model. The oscillator process works very well when a rhythm or pattern is present because the oscillator notices certain regularities. In other words, the oscillator can pick up on a rhythm and 'predict' when the next beat should occur in that rhythm. Proponents of the oscillator model argue that rhythm is present in various forms in nature like biological rhythms, bird song, and the ebb and flow of the ocean. As such, humans have a dedicated mechanism to pick up on such rhythms. One such an example is Jones and Boltz's (1989) dynamic attending theory (DAT). DAT stipulates that the accuracy of temporal estimates depend on attending internal rhythms to synchronise with external rhythms.

It is clear that the pacemaker-counter and oscillator variants of internal clock models have different strengths and weakness when it comes to explaining time perception. For example, oscillator models are good at explaining our ability to pick up on and predict patterns in timing like a drummer keeping a steady beat. However, oscillator models come up short when explaining perception of non-rhythmic or single temporal events like how long you have been reading this report. Pacemaker-counter models on the other hand, are great at explaining estimates of single temporal events.

The role of attention in time perception is a recurring theme. For example, SET was originally developed to explain animal timing behaviour. The critical difference between animal and human time perception is the role of attention. In animals, attention is of little significance, but in humans, it is vital (Brown, 2008). Consequently, the attentional-gate model is similar to SET, but it introduces the role of attention in time perception. According to the attentional-gate model, a 'gate' controlled by attention determines when the counter will store pulses, or not. The attentional-gate model purports that in order to keep track of time, attention must be paid to the task of timing. The model holds water in the prospective paradigm of time perception where participants are told to attend to the task of timing. In the retrospective paradigm the role of attention changes considering that participants cannot actively pay attention to the task of timing, because they are unaware that a duration estimate will be required. Consequently, these participants are more attentive to the non-temporal features of the experimental task and as such, their temporal attentiveness is relatively low (Brown, 2010).

Another model of time perception that relies on the role attention plays in timing is the segmentation model. The segmentation model purports that time perception is determined by changes in the stimulus environment (Poynter, 1983). Perceived changes are relative to the ease with which they can be segmented into distinct events. The more segments are created, the greater the perceived duration length. Attention plays a role in the segmentation process: participants are better able to segment the elapsed duration into distinct events based on how much attention they pay to the events. Someone who is paying a lot of attention to perceived events are likely to estimate the duration as longer because they were able to segment more distinct events (Block et al., 2010). Adherents of the segmentation model argue that during a pleasant event, attention is drawn away from timing affecting the segmentation process and resulting in shorter duration estimates.

The contextual-change model, which is essentially a variant of the segmentation model, holds that some types of cognitive load lengthen perceived durations (Block et al., 2010). Similar to the segmentation model, the contextual-change model argues that the more changes occur in the environment, the greater the duration estimate will be. This is to say that the more cognitively engaging an event is, the longer it will be perceived to be. In the context of the present research, this is to say that the more difficult the experimental task is, the greater cognitive load will be and the longer the duration judgement will be.

In the retrospective paradigm, the contextual-change model relies heavily on the role memory plays in time perception (Block & Gruber, 2014). As the target duration is no longer present when the duration estimate is required, all that is left are the memories of the event. According to the contextual-change model, our memory is trying to retrieve all the information stored during the duration. This is to say that the more information is stored during the target duration, the longer the duration estimate will be. This is based on the naïve assumption that the more information was stored during the target duration, the longer the duration must have been.

There are two obvious flaws in the logic of this model. Firstly, the amount of information stored in memory during the target interval is not solely determined by the length of the interval, but by a myriad of other factors (Zakay, 2012). One such factor is the intensity or difficulty of a task performed in the target duration. Solving a difficult maze will result in greater amounts of information processing than doing nothing, thus resulting in greater duration estimates. A second factor is the amount of contextual changes that occur during the target duration. This is because contextual changes like changes in lighting conditions or temperature are stored in memory along with other aspects of the experimental task. All these bits of information will be retrieved simultaneously when a duration judgement is required, thus, resulting in longer duration estimates for target durations with greater amounts of contextual changes. Block and Reed (1978) demonstrated this in a classic study where participants were given the exact same experimental task. One group of participants experienced contextual changes in room lighting, while the other group experienced no such changes. Participants in the contextual-change group estimated the target duration as longer than participants in the group with no contextual changes.

In additional to the first flaw, the second flaw is capacity problems of memory. Cognitive scientists are not in agreement as to what the capacity of human memory is, however, they are in agreement that working memory is finite (Goldstein, 2008). This begs the question what will happen to information in memory (including timing information) once memory capacity has been reached as a result of contextual changes. The contextual-change model of time perception does not account for the possibility of reaching memory capacity.

The contextual-change model suggests that changes in the type of information processed, the context or the mood experienced during target durations have a high probability of being retrieved from memory. As such, retrospective duration judgements, according to the contextual-change model are actually based on the amount of changes of any sort that occurred during the target duration (Block & Reed, 1978). A recent review of the literature concludes that the contextual-change model is the best model of time perception to explain retrospective timing (Block & Gruber, 2014).

Dedicated models of time perception have their use, as explained above, however, not all models are able to explain all the different and seemingly paradoxical results often found in time perception studies. For example, one interesting finding in the field of time perception that internal clock models struggle to explain is the discrepancy between temporal judgements of the same objective length, but different sensory modalities. For example, visual stimuli are perceived as shorter than auditory stimuli of the same length. Consequently, it is potentially valuable to explore the other branch of time perception models – intrinsic models – to see if they are any better at explaining such findings.

Intrinsic models: no internal clock. It can be argued that intrinsic models of time perception are similar to dedicated models except in that intrinsic models apply Ockham's razor to explaining time perception, as they are often viewed as simplified version of their dedicated counterparts. This is because cognitive mechanisms like memory and attention, or neural dynamics explain time perception without the need to rely on an internal clock (Ivry & Schlerf, 2008). Thus, it can be argued that the intrinsic model provides a simplified, but equally successful explanation of time perception. This section will argue for the merits of intrinsic models of time perception as well as their shortcomings.

The intrinsic model purports the existence of modality specific mechanisms related to time perception. For example, Morrone, Ross and Burr (2005) found that saccadic eye movements – when the eye tracks an object across the visual field – affects duration judgements of visual stimuli, but not of auditory stimuli. In other words, when participants had to track an object in the visual field and estimate the duration of an interval, their estimates differed based on the modality of the stimulus indicating the start and end of the interval. Intervals indicated with a visual stimulus (i.e. a flash of light) were judged as shorter than intervals indicated with an auditory stimulus (i.e. a click sound). Also, Grondin et al. (2005) found that time perception loses accuracy when intervals are signalled by different modalities like a beep indicating the start of an interval and a flash indicating the end of the interval. In such cases, estimates are further off when compared to intervals signalled by modality specific stimuli, in other words either beeps or flashes, but not a combination of the two, are likely to result in the most accurate timing estimates. Internal clock models struggle with such findings because there is no reason for the internal clock to detect modality specific stimuli differently.

Not all intrinsic models concur on the sensory specificity of time perception, however, some intrinsic models purport that time perception is a function of the inner workings of neural networks (Ivry & Schlerf, 2008). The ability to perceive time, according to such models, is limited to neural regions that are capable of sustaining activity without sensory input. Support for these models come in the form of delayed response tasks were participants have to keep information pertaining to the task in working memory prior to commencing with the task. The activity of the neurons firing to keep the information in working memory encodes the information with a 'time stamp'.

A variation on this model is that time is coded in the magnitude of neural activity. Henson and Rugga (2003) found that if exactly the same stimulus, for example the number 1, is presented repeatedly for the same amount of time, duration judgements will decrease from the second repeat. In other words, the first time the 1 is shown, will be perceived the longest and subsequent presentations will be judged as shorter than the first. This is because the first time the 1 is presented, it is not expected and it piques participants' interest. The second time the 1 is presented, is not as novel as the first time and the participant quickly comes to expect the next stimulus to be a 1, making the duration between stimuli feel shorter. Similarly, when numbers are presented in the correct order, for example, 1 2 3 4 etc., the 1 receives the most attention and so also results in the longest duration judgement. However, when the numbers are presented out of sequence, for example, 2 4 1 3, each number receives the same amount of neural processing because it is equally unexpected and consequently evokes the same duration judgements.

Evidence from neuroscience tends to support intrinsic models of time perception. For example, time perception studies using fMRI have demonstrated that several areas of the brain are active during timing tasks. The activated areas are related to cognitive processes like attention, working memory and decision-making, which seems to indicate that there is no use in assuming the existence of an internal clock that uses the exact same complex timing system of neural networks (Wittmann, 2009). The complexity related to the number of areas active during time perception implies that a breakdown at any point in the system will lead to a failure of the entire system: hence, impaired time perception.

In summation, both dedicated and intrinsic models of time perception have their strengths and weaknesses, but the contextual change model which forms part of the dedicated models of time perception best explains timing in the retrospective paradigm. The model explains how people are able to make fairly accurate durations judgements based off nothing but their memory of events and also explains why cognitive load increases duration judgements in the retrospective paradigm as a consequence of the increased number of contextual changes evident in high cognitive load conditions. The researcher consequently adopts a contextual-change model of time perception as the model underlying time perception in the present research.

Role of attention in time perception. The role of attention in time perception can be explained at the hand of the attentional-gate model of time perception (Brown et al., 2010). As stated in the previous section, attention controls the 'gate' that affects the amount of pulses counted during time perception. According to the model, the role of attention in time perception depends on the paradigmatic point of departure. In the prospective paradigm, participants can focus at least some of their attention to the task of timing. This tends to lead to longer duration estimates as the 'gate' allows more pulses to pass because it is focused on timing. In the retrospective paradigm, attention is directed away from timing and any attention paid to the elapsed time is coincidental. This leads to shorter duration estimates, because the 'gate' allows few pulses through since it was otherwise occupied. The role of attention in retrospective time perception is incidental.

Researchers found that increasing task difficulty decreased duration estimations in the prospective paradigm (Brown et al., 2010). The attentional-gate model explains this finding by purporting that as task difficulty increases, cognitive load increases, this in turn results in attention being directed away from timing and toward the distractor task, resulting in fewer pulses passing through the 'gate' and shorter time perception. In the retrospective paradigm, the attentional-gate model has little significance because no attention is paid to timing.

Role of memory in time perception. By definition, memory plays a key role in retrospective time perception. Our memory of an event is what we rely on to estimate how much time passed during the event. Similarly, episodic memory can be used to estimate a task or event length. It is theorized that our memory of other events and their durations can also influence present time perception through a type of comparison-decision-making process. Also, working memory plays a role in prospective timing as the amount of information that can be stored in memory ultimately influences a person's ability to perceive time (Goldstein, 2008).

Recent research purports that infants learn to time because of the memory-trace decay of everyday events (Addyman, French, Mareschal, & Thomas, 2011). The model suggests that time perception is not a capacity that humans are born with, but our memory of certain events and the way in which the memories fade with time, teaches us to perceive time accurately. The model also holds that the role of memory in time perception is bigger than what some models put forth, because without memory, time perception is severely impaired. This is also seen in patients with Alzheimer's diseases and Schizophrenia where patient's memory capabilities are severely impaired and so also their time perception (Wittmann, 2009).

In addition, Block and Gruber (2014), found that some information related to time perception is encoded in memories as is evidenced by the ability to determine recency, frequency, temporal order, and the duration of a task or an event.

Methods of studying time perception

There are three main methods used to study time perception from a cognitive perspective. These include production, estimation and reproduction. The methods are often used when studying the effect of for example gender or age on time perception or to investigate the role of attention or memory in time perception (Grondin, 2008). In addition to these three main methods, some researchers consider there to be a fourth method called the method of comparison and this involves deciding which of two presented intervals are longer. This method is most useful to study the perception of short intervals as it relies on "just noticeable difference[s]" (Grondin, 2008, p. 54) between intervals.

Production methods are techniques where the participant is required to produce a duration similar to a target duration for example by holding a button down for a period that seems like the target period. This method of studying time perception is not relevant to the retrospective paradigm as it requires participants to be aware of timing in order to produce a target duration. This is because participants are instructed to produce an interval of say 11s.

Estimation methods require participants to make a verbal judgement of the target duration and articulate this judgement either by saying or writing down the amount of time in conventional time units (i.e. seconds, minutes or hours). Estimation methods can be used in both prospective and retrospective paradigms as it does not require participants to pay attention to timing as they can use their memory to recall and then estimate the target duration. This is the method used in the present research.

Production and estimation methods are similar in the sense that both methods require participants to compare a target duration with information stored in memory regarding conventional time units. The trouble with using conventional time units is explained in more detail in the section on moderating variables. The key issue is that very young participants (younger than seven years of age) do not have a well-developed grasp on conventional time units resulting in greater variability in their reported time perception when using estimation methods (Addyman et al., 2011). Another problem with using conventional time units is that it can be very hard for participants to estimate short supra-second intervals to the nearest second simply because most people are not used to thinking about time in such an exact sense. Participants tend to round their duration judgements up to the nearest thirty second or half-minute interval (Grondin & Plourde, 2007). This can be problematic when studying timing in the region of 120s as a large part of the variability in estimates can then be attributed to the vague response and not to the perception of time.

The third and final method used in time perception research is known as reproduction methods and can be classified as somewhere between production and estimation methods. In reproduction methods the participant is required to reproduce the target duration by for example tapping on a table. Females tend to make shorter reproductions than males, but the effect size is not statistically significant (Block et al., 2000). Reproduction methods are similar to production methods in that both required an operative (physical) estimation, and similar to estimation methods because both require participants to estimate an experienced duration. Theoretically speaking, reproduction methods can be used in the retrospective paradigm, however, they are seldom used in the retrospective paradigm because each participant would only be able to make one retrospective reproduction before they become aware of time. This means that retrospective time perception studies using reproductive methods would require exponentially large sample sizes to account for this.

Both production and reproduction methods are especially vulnerable to participants wanting to end the experiment quickly as a consequence of boredom and any other reason related to being in a hurry to leave. This would lead to participants underestimating the target duration.

An additional aspect of the methods used to study time perception is whether the target interval is filled or empty (Brañas-Garza, Espinosa-Fernández, & Serrano-del-Rosal, 2007).

An empty interval is a target duration that is indicated by a brief signal like a light that flashes or a beep sound preceded by silence or no visual stimulus and then the end of the target duration is again indicated by a brief signal. The modality of the signal could affect time perception and varied results have been found when different modality signals are used to indicate the start and end of the target duration. Furthermore, if the signal is long, for example a light that stays on for a couple of seconds or a long beep sound, it becomes more difficult for participants to accurately estimate the target duration (Grondin, 2008). This is most likely because they do not know whether the target interval start at the start or end of the first beep or flashing light and they do not know whether it ends at the start or end of the last beep or flashing light. A filled interval is when the stimulus indicating the start and end of the target interval runs continuously. In other words, the target interval starts when the beep or light starts and end when the beep stops or the light is switched off. Filled intervals tend to be judged more accurately because there is no ambiguity as to when the interval starts or ends.

The final aspect of the method of studying time perception that is of importance is whether it is a dual-task or single-task situation (Grondin, 2008). Dual-task situations involve participants to keep track of time while simultaneously performing a non-temporal task like reading a text, counting cards, doing mental arithmetic, playing a video game or any other kind of additional task. The experimental task usually impacts on the amount of attention paid to the task of timing (in the prospective paradigm) or the amount of information processed (in the retrospective paradigm). According to models of time perception relying on attention, duration judgements decrease as more attention is paid to the experimental task. Memory models of time perception purport that duration judgements increase as more information is encoded in memory as a result of the experimental task.

Dual-task situations have the benefit of studying the relationship between time perception and various independent variables. For example, a participant's emotional state can be manipulated under dual-task conditions if they are required to watch a sad film (Droit-Volet & Meck, 2007). On some occasions, dual-task situations can include two concurrent temporal tasks (Grondin, 2008), like keeping track of a target interval while tapping out a rhythm.

Theoretical definitions of variables

Defining cognitive load. Cognitive load is defined as the amount of mental effort demanded by a specific task or tasks at any particular moment (Block et al., 2010; Feinberg & Murphy, 2000). This definition points to the fact that cognitive load is strongly linked to task difficulty. The more difficult a task is, the higher the cognitive load will be on the person completing the task. According to Goldstein (2008), a high cognitive load task is one that uses all of the person completing the task's cognitive resources, leaving little or no capacity left to handle other tasks. This is in-line with models of time perception relying on attention, that stipulate that under high cognitive load conditions, time perception decreases as there is little or no capacity left for timing. Models of time perception relying on memory, on the other hand, argue that under high cognitive load conditions, more information is processed and stored in memory leading to longer duration estimates.

Manipulating cognitive load can be as simple as increasing task difficulty. According to Block et al., (2010) cognitive load can be manipulated by telling participants that they have to try and remember presented information for a test that will follow. This type of manipulation works well in the retrospective paradigm of time perception research because it relies on the same memory systems that are taxed in making the duration estimates. This is referred to as an intentional-memory condition.

Cognitive load and pupil dilation. Cognitive load can be measured using eye tracking equipment that record pupil dilation. Classic past research suggests that pupil dilation is an accurate indicator of cognitive load (Hess & Polt, 1964; Kahneman & Beatty, 1966). Current research corroborates these findings arguing that pupil dilation indicates a state of high cognitive load and pupil contraction indicates low cognitive load (Duchowski, 2007). This is because pupillary activity is in some part controlled by the sympathetic nervous system (SNS) along with other emotional responses (Zillmer, Spiers, & Culbertson, 2008). As such, eye tracking equipment can be used to measure pupil dilation and in turn cognitive load.

The link between pupil dilation and cognitive load is slightly more nuanced. According to Van Gerven, Paas, Van Merrienboer, and Schmidt (2004), age seems to play a role in pupil dilation. Van Gerven et al. (2004) found varied results between a group of students (mean age 20.4 years) and a group of elderly individuals (mean age = 68.6 years). Participants had to complete a two-phased memory-search task. The first phase involved encoding a string of numbers to memory, whereas the second phase involved comparing the string in memory to a string presented on-screen as either the same or different. In the memory phase, both groups showed comparable pupil dilation, whereas in the second phase, the group of students showed greater dilation than the elderly group. The interesting finding is that the elderly group experienced greater cognitive load than the students during the second phase. Van Gerven et al. (2004) also found that pupil dilation among the students seemed to increase along with cognitive load, but these same results were not found in the elderly. In other words, age therefore causes inconsistent pupil dilation and the observed variation between participants. Consequently, age could potentially be a confounding variable, seeing as how pupil dilation is not strongly correlated with cognitive load in older individuals.

Research also suggests that once cognitive load approaches or exceeds processing limits, pupil dilation ceases to be an accurate measure of cognitive load. Granholm, Asarnow, Sarkin, and Dykes (1996) found that pupil dilation increases systematically with cognitive load until it reaches the processing limit and then starts declining. According to Granholm et al. (1996), these findings are not task specific and hold true regardless of whether sensory, memory, language or reasoning functions are required to perform the task. It is therefor, important that the high cognitive load condition of both of the research tasks is not too high, in order to avoid reaching processing limits evidenced by a drop in pupil dilation. If pupil dilation starts to drop, the researcher cannot argue whether this drop is related to a decline or increase in cognitive load. The exact limit of cognitive load is not of interest, but it is worth noting that the high cognitive load condition should not be too difficult, but just be more difficult than the low cognitive load condition. The purpose is not to push participants' limits, but to demonstrate different levels of cognitive load.

Furthermore, pupil dilation is related to sympathetic and parasympathetic nervous system activity. These two systems form part of the autonomic nervous system (ANS) which is responsible for controlling organ functions (Zillmer et al., 2008). The sympathetic nervous system expends energy and the parasympathetic nervous system acts to conserve energy. Consequently, pupil dilation for example is affected by lighting conditions (low light leads to increased dilation and vice versa), and the effect of pharmacological substances (Steinhauer, Siegle, Condray, & Pless, 2004).

A consequence of the link between the ANS and pupil dilation is the effect emotional arousal has on pupil dilation. Partalaa and Surakka (2003) demonstrate that pupil dilation is significantly increased for negative emotional stimuli when compared to neutral stimuli. The potentially confounding effect of presenting participants with negative emotional stimuli is avoided in the present research because no negative emotional stimuli are used. This is in fact linked to the level of arousal produced by emotional stimuli and the effect it has on participants. As an example, a negative emotional stimulus with high arousal could be exposing participants to pictures of a gruesome car accident.

Link between time perception and cognitive load. According to Block et al. (2010), it has been demonstrated that a strong link between time perception and cognitive load exists. According to Brown (2008), time perception depends on whether attention is focused on the passing of time. In other words, when attention is distracted from time, it seems to pass quicker. By focusing on the primary task (like in the retrospective paradigm) time will seem to pass quicker (Sucala, Scheckner, & David, 2011).

The suggested link between cognitive load and time perception is explained by either attentional resource or memory theories of time perception (Block et al., 2010). On the one hand, attentional resource theories argue that attention is a precious cognitive resource that is limited (Kahneman, 2011). As such, one is required to *pay* attention from a limited pool of cognitive resources, directing attention away from the task of timing toward the completing the experimental for example reading the provided text. Attentional models of time perception explain the link between cognitive load and time perception in the prospective paradigm (Sucala et al., 2011). In the prospective paradigm, as cognitive load increases more and more attention is directed toward completing the experimental task and less attention is paid to the task of timing, resulting in reduced estimates of interval length. In other words, as cognitive load increases in the prospective paradigm, time perception decreases relative to chronological time.

Increasing participants' cognitive load through performing a difficult experimental task (for example, reading a difficult text), will most likely tax their attentional resources to the extent that their duration judgments are likely to be influenced. The effect on time perception occurs because the duration judgments are regarded as of lesser importance (Eagleman, 2008), and fewer precious cognitive resources will be directed to time perception.

On the other hand, models of time perception relying on memory argue that the more difficult the task is the more information becomes encoded in memory leading to greater duration estimates (Sucala et al., 2011). These models best explain time perception in the retrospective paradigm as memory systems are taxed when recalling the length of the remembered duration. However, this relationship has not been demonstrated consistently

(Tobin & Grondin, 2009). Hicks et al. (1976) found no effect between increased cognitive load and time perception in the retrospective paradigm. Participants were required to sort playing cards for 42s by paying attention to either zero, one or two bits of information per card. When participants were warned ahead of the task that a duration estimate would be required at the end, participants in the high cognitive load condition duration estimates were shorter. When participants were not warned that a duration estimate would be required, no statistically significant difference was found between the low cognitive load and high cognitive load conditions.

Block and Zakay (2001) argue that this finding is due to the length of the target interval. Memory based models of time perception argue that the more information is processed, the longer the remembered duration will be. Thus, for shorter durations, there seems to be little to no effect between increased cognitive load and increased remembered durations.

According to Brown's (2008) review of the literature a total of 49 articles with 72 individual experiments consisting of at least two levels of experimental task difficulty have been published between 1938 and 2008. These experiments explore the role of cognitive load as a function of task difficulty on time perception. Brown (2008) found that 67% of these experiments (48 in total) reported that increased cognitive load leads to greater variability in time perception. In other words, there is strong evidence to demonstrate that increased cognitive load decreases participants' ability to judge time accurately. There also seems sufficient support to conclude that prospective duration judgements decrease as cognitive load increases and retrospective duration judgements are either unaffected or increased as cognitive load increases (Brown, 2008; Khan et al., 2006).

Defining emotion. Emotion can be defined as a response of the participant with three major components. These components include physiological arousal, expressed behaviour like facial expressions, and conscious experience (Droit-Volet & Meck, 2007). For the purpose of the current study, emotion is defined only in terms of conscious experience. Participants will be asked to report on the emotions they experienced while performing the experimental task.

The reason for this narrow definition is because the current study is only interested in two primary emotional states: positive and neutral emotion. Participants should be able to report on both of these emotional states reliably (Youngstrom & Green, 2003). To induce positive emotions in participants, the primary task will be a fun activity like playing a computer game (Chan, 2010; Sim, MacFarlane, & Read, 2006), in the experimental condition and a reading task in the control condition will induce a neutral emotional state (Tobin & Grondin, 2009). The tasks are discussed in more detail in the methodology section.

Link between time perception and emotion. Time perception entails emotional and internal states (Wittman, 2009), however, the exact link between time perception and emotion is unclear (Droit-Volet & Meck, 2007). Many studies investigating the link between emotion and time perception include other variables. These studies usually look for interactive effects and do not specifically focus on main effects. As such, a nuanced approach to discussing the link between time perception and emotion is the best way forward.

The influence of emotions and arousal on time perception is probably one of the most interesting and nuanced relationships in time perception literature. For example, Noulhaine, Mella, Samson, Ragot and Pouthas (2007) investigated the influence of emotional valence (pleasant/unpleasant) and arousal (low/high) on time perception. The researchers found that emotional sounds were judged longer than neutral sounds for durations up to four seconds. This effect occurred for both positive and negative emotions, however, negative emotional sounds were judged the longest. In the high arousal conditions, auditory stimuli were judged as shorter than low arousal conditions of the same time.

Angrilli et al. (1997) argue that the interactive effect of valence and arousal on time perception is complex. The researchers presented participants with visual stimuli. They found that in the high arousal conditions, negative emotional stimuli resulted in the overestimation of durations, however, positive emotional stimuli resulting in underestimation of durations. When one compares the results of the Noulhaine et al. (2007) study to that of the Anrilli et al. (1997) study, one can see that the influence of emotion and arousal on time perception is not linear. In other words, two studies comparing the effect of similar variables (emotion and arousal) ended up with contradictory findings. In one study, the researchers found that the emotionality of stimuli is a better predictor of the influence on time perception, and the other study found no main effects, only an interaction effect.

Droit-Volet, Brunot, & Niedenthal (2004) investigated the influence emotional visual stimuli have on time perception. In their study, participants were presented with angry, happy or sad emotional faces for either short or long durations. A baseline for the durations was established using neutral faces. Droit-Volet et al. (2004) found that duration judgements for emotional faces, regardless of the emotion, were consistently greater than duration judgements of neutral faces. Droit-Volet et al. (2004) concluded that emotional arousal increase the pace of the internal clock.

Subjective duration judgements decrease when positive emotion increases, however, duration judgements tend to increase when experiencing boredom (Wittman, 2009). Tobin and Grondin (2009) demonstrated that a fun task like playing Tetris decreased participants' time perception compared to a neutral reading task of the same length.

Experiencing certain emotional states can even affect time perception of subsequent events, for example experiencing fear will increase subsequent duration judgements (Droit-Volet et al., 2011). Participants looking at emotional faces displaying, for example anger and sadness, tend to overestimate the time the emotional faces were displayed compared to neutral faces (Droit-Volet et al., 2004).

These findings suggest the existence of a strong link between time perception and emotion, however, the relationship is not clearly understood. Negative emotions like anger tend to increase time perception and positive emotions like happiness tend to decrease time perception (Droit-Volet & Meck, 2007; Wittman, 2009). However, some negative emotions like fear and anxiety sometimes have the paradoxical effect of decreasing time perception. This is most likely due to the level of arousal induced by the emotional stimuli (Angrilli et al., 1997).

For the purpose of the proposed study, only positive emotion (i.e. happiness) and a neutral emotional state will be investigated. This is because the literature with regards to the link between these emotional states and time perception concurs and consequently simplifies the inquiry.

Link between emotion and pupil dilation. Early research into the link between emotion and pupil size variation seemed to indicate that pupil dilation was on a continuum with extreme dilation related to the most pleasant emotional stimuli and extreme constriction related to the most unpleasant emotional stimuli (Hess, 1972). This idea was soon refuted as little evidence could be found to support the notional that emotionally unpleasant stimuli led to pupil constriction. Rather, it was suggested that the intensity of the emotional stimuli, in other words the extent to which an emotion was pleasant or unpleasant, was related to pupil dilation. That is to say that emotionally arousing stimuli, both positive and negative emotions, are related to pupil dilation and emotionally neutral stimuli are related to pupil constriction (Janisse, 1974).

More recent research has found support for Janisse's (1974) notion that pupil dilation is in a curvilinear relationship with emotional valence. Siegle et al. (2003) found that emotionally arousing stimuli can increase pupil dilation. Similarly, according to a study by Partalaa and Surakka (2003), pupil size increases significantly after participants hear an emotionally positive or negative sound. Examples of such sounds include a baby laughing or crying. These sounds are said to be highly arousing, leading to an ANS response. Bradley, Miccoli, Escrig, and Lang (2008) found that pupil dilation increases when participants are shown emotionally arousing pictures. Again, pupil dilation increased regardless of whether the pictures were pleasant or unpleasant.

In order to make sense of these findings, it is worth discussing the link between pupil dilation and the nervous system functioning in more detail. Changes in pupil diameter are controlled by two muscles namely the dilator and the sphincter. These muscles are differently influenced by activity in the two branches of the ANS. The ANS is responsible for regulating the body's internal environment and it does this through its two divisions: the sympathetic and parasympathetic nervous systems. These two divisions can be viewed as two sides of the same coin. The sympathetic and parasympathetic nervous systems tend to act in opposite directions with the sympathetic nervous system expending energy and the parasympathetic nervous system conserving energy (Zillmer et al., 2008).

Increased activity in the sympathetic nervous system increases the activity of the dilator muscle, leading to pupil dilation. Decreased activity in the parasympathetic nervous system is related to the relaxing of the sphincter muscle, which also results in pupil dilation. In other words, if activity in the sympathetic nervous system increases, the pupil will dilate. Similarly, if activity in the sympathetic nervous system's counterpart, the parasympathetic nervous system increases, the pupil will contract. Therefore, pupil dilation is related to increased sympathetic nervous system activity (Bradley et al., 2008).

Activation of the sympathetic nervous system is related to increased blood flow, heart rate and blood pressure. In other words, the sympathetic nervous system mobilises the body for emotional arousal (Zilmer et al., 2008). Hence, the observed link between pupil dilation and emotional stimuli.

In reference to research conducted on the link between emotion and pupil dilation, no effect was found for neutral sounds, however, Partalaa and Surakka (2003) found that pupil dilation among female subjects were systematically larger than male subjects when subjects are presented with emotionally neutral stimuli. Also, females showed somewhat greater pupil dilation to emotionally positive stimuli than males and males demonstrated slightly greater pupil dilation for emotionally negative stimuli than females. That is to say that the pupils of females tend to be more dilated than their male counterparts as a base measurement. The main effects for gender were not statistically significant, though. On the other hand, Bradley et al. (2008) only used female participants, so no gender differences could be identified.

In summary, pupil dilation can be the result of emotional stimuli either positive or negative. When using pupil dilation as a physiological measure of cognitive load, this effect of the sympathetic nervous system on pupil dilation should be taken into account. If participants' pupils dilate during the experimental tasks, it might be as a consequence of the manipulation of emotional states instead of the manipulation of cognitive load. This is to say that an additional manipulation check – like a self-report questionnaire – is needed to ensure that both independent variables are successfully manipulated by the researcher.

Link between cognitive load and emotion. Evidence from neuroscience suggests two possible links between cognitive load and emotion. Firstly, increased cognitive load can decrease the effect of negative emotional stimuli (Van Dillen, Heslenfeld, & Koole, 2009). In an fMRI experiment Van Dillen et al. (2009) subjected participants to negative emotional stimuli in the form of pictures with negative valence like a child crying (negative emotional valence condition). Thereafter, participants had to complete a difficult mathematical calculation (high cognitive load condition), or an easy arithmetic task (low cognitive load condition). The researchers found that the difficulty of the arithmetic task decreased the effect of the negative emotional stimuli. Participants reported experiencing less negative emotions after completing the difficult arithmetic task. Also, the fMRI results revealed decreased activity in the emotional regions of the brain approximately 6 seconds after being given the arithmetic task.

Secondly, regulating emotions can increase cognitive load (Scheibe & Blanchard-Fields, 2009). Emotional reappraisal or regulating emotions is said to influence cognitive load most likely because it taxes working memory. The researchers demonstrated this in an experiment where participants were asked to regulate their emotions after watching a "disgust-inducing" film clip (p. 1) and then complete the famous N-back test (Scheibe & Blanchard-Fields, 2009). The N-back test becomes increasingly difficult as participants are expected to match the current number to the N-th number back in the sequence of randomly generated numbers. As the N-th number increases, cognitive load increases as a result of working memory taxation. The researchers found that participants' performance on the N-back test decreased when they were requested to regulate their emotional state. This effect did not occur when participants were not told to regulate their emotional state.

Consequently, cognitive load and emotion can influence each other reciprocally. This is to say that regulating causes increased cognitive load and under conditions of high cognitive load tasks, participants are not able to regulate negative emotion. In the aforementioned situation, it stands to reason that regulating emotion increases cognitive load beyond the point where participants can function successfully, leading to reduced performance on high cognitive load tasks. For the purpose of the proposed study, it is important to note that the relationship between emotions and cognitive load seems to exist only when some attempt is made at regulating emotions.

Participants in the present study are not asked to regulate their emotion nor are they required to endure negative emotions. As such, it would appear that there is no mediating link between emotions and cognitive load that would regulate the relationship between these two variables and time perception in the present research. The relationship between emotion and cognitive load appears to be of little interest to the present study.

Moderating variables

This section will discuss the roles several moderating variables play in time perception. The section starts off with a discussion on the relationship between gender and time perception, as well as the three identified factors that moderate this relationship. Thereafter, age as moderating variable will be discussed by looking at a developmental perspective of timing.

The role gender plays in time perception is a contentious issue. For example, Hancock, Vercruyssen, and Rodenburg (1992) demonstrated differences between males and females with regards to their duration judgements but referred to said differences as "equivocal" (p. 203). Some researchers find no gender differences (Marmaras, Vassilakis, & Dounias, 1992), but in the cases that gender differences are demonstrated, women tend to overestimate durations (Espinosa-Fernandéz et al., 2003). Findings from Block et al. (2000) corroborate this, concluding that men tend to be more accurate when making duration estimates compared to women. In other words, variability in duration estimations was greater among women than among men.

Three factors appear to moderate the relationship between gender and time perception. Two of these are methodological factors and include the method used and number of trials in the experiment (Block et al., 2000). Firstly, when using production methods women tend to underestimate target durations when compared to men, who seem to estimate time quite accurately (Hancock & Rausch, 2010). Production methods, as mentioned earlier, are only used in the prospective paradigm and the moderating effect is not of consequence to the present research. On the other hand, when using estimation methods females tend to overestimate target durations and males tend to underestimate target durations (Block et al., 2000). This could be of value to the present research as the study utilises verbal estimation as method of time perception.

Secondly, the number of trials also seems to have a moderating effect as studies using multiple trials or repeated measures appeared to demonstrate gender differences (Hancock & Rausch, 2010). Studies using single measures tend to demonstrate statistically not significant or no gender differences.

The third factor that appears to moderate the relationship between gender and time perception is participants' age (Brañas-Garza et al., 2007). As participants' age increases, a greater difference in time perception between males and females is observed. For example, the older the females, the more they tend to overestimate target durations when using estimation methods. Also, variability between males and females with regards to time perception increases the younger the participants are. Brañas-Garza et al. (2007) found that participants younger than 21 years of age demonstrated more gender differences than participants aged 21 and up.

Piaget (1969) reasoned that temporal cognition was gradually acquired during several developmental stages. Until a child has developed through those stages, their temporal thinking differs significantly from that of an adult. Younger children tend to overestimate target durations compared to older children (Block et al., 1999), however, children younger than 7 years of age struggle to make duration judgements using estimation, because they have not yet learned to use conventional duration units (seconds, minutes and hours) in a reliable way (Pouthas, 1993). It is therefore arguably ill advised to use young children in time perception studies where the method of perception is verbal estimation, like in the current research.

Research from gerontological literature show a progressive reduction in ability of subjective timing (Hancock & Rausch, 2010). This is to say that as participants get older their psychological time deviates more and more from objective time. Methods that require reaction time, like production and reproduction can also be hampered by physical disabilities related to age. Espinosa-Fernandéz et al. (2003), found that as participants aged, they tended to under produce or underestimate target durations. Gender also seemed to exacerbate such findings with women under producing target durations more than men. Complicating the matter even more, there is significant variation in individual differences when it comes to ageing, so it is near impossible to say at exactly what age and to what extent people start to lose the ability to perceive and reproduce target times accurately.

The role age plays with regards to time perception in the retrospective paradigm is not as well researched with several studies focusing on the prospective paradigm (Block et al., 1999). Wittmann and Lehnhoff (2005) found that time perception is influenced by chronologic age in the retrospective paradigm with older participants underestimating target durations. Results from their research seem to support the notion that psychological time speeds up with age. This could perhaps be attributed to the influence of memory on retrospective time perception and the effect ageing has on memory. The hybrid cognitive-physiological models like the attentional-gate model purports that age may affect any of the processes related to psychological timing, for example arousal levels which influence the speed of the pacemaker and the attentional gate which will influence the amount of temporal information stored in memory.

Determining the individual contributions of the variables age and gender on time perception is problematic. There are a number of research studies investigating the joint effect (Brañas-Garza et al., 2007; Espinosa-Fernandéz et al., 2003; Hancock & Rausch, 2010). It would appear that time perception is significantly influenced on both extremes of the age continuum. Considering these findings, it would make sense to use a cohort of participants to avoid the moderating effect extreme age has on time perception.

In additional, boredom and boredom proneness (BP) are other factors that play a role in time perception. According to Watt (1991), BP is a psychologically measureable trait that can influence people's ability to perceive time accurately. This predisposition to experience boredom was associated with risky behaviour like risk taking while driving, as well as diminished performance efficiency (O'Hanlon, 1981). Considering the study population is senior students in the psychology department, it is not likely that participants with trait BP would form part of the sample as the population are high achieving individuals in a highly competitive environment. However, the researcher will not test for BP and it could potentially moderate or confound participant scores on time perception.

Boredom is said to be an emotional state of restlessness that is characterised by a lack of interest. This lack of interest can inadvertently be manipulated by the researcher by selecting tasks in the experimental conditions that do not captivate participants' interest. Boredom is likely to result in overestimations of time. Zakay (2014) notes that when cognitive load is below an optimal level, then the person will start to feel bored. This optimal level differs from individual to individual and is linked to a situation in which most of one's attentional resources are free and are not allocated to a specific task which demands information processing (Block & Gruber, 2014). Similarly, boredom is associated with decreased cognitive efficiency and mental performance (Zakay & Block, 2004). Despite the optimal level of cognitive load differing between participants, the researcher expects that boredom is not likely to play a role in the present research because participants will complete various tasks for short durations at a time and at varying levels of cognitive load. The low cognitive load conditions are of particular interest as participants might be more likely to become bored during these less challenging tasks. The researcher therefore selects a reading task and a game task that is still relatively challenging and likely to induce low cognitive load, but not boredom.

In summary, there are many moderating variables and some variables that could potentially confound the findings of the present research. The researcher must take special care to control for participants' age and gender as far as is practical and possible. Similarly, participants can become bored with the experimental tasks and this could influence their time perception. To control for these moderating variables, the researcher sampled a cohort of participants and attempted to sample as many females as males. Furthermore, the researcher keeps the experimental tasks and overall participation in the present research as short as possible and within acceptable limits (Tobin & Grondin, 2009), to prevent participants from becoming bored.

Chapter 3: Methodology

This chapter discusses the methodology of the present research. The chapter looks at the research question and hypotheses guiding the investigation, moving onto the research design, the sampling methods and measurement instruments used, and ends off discussing the data collection and data analysis procedures.

Hypothesis

The research question guiding the current study is: What is the influence of positive emotion and cognitive load on time perception in the retrospective paradigm? Accordingly, the research and null hypotheses are:

H_1: $\mu_{Text1Time} \neq \mu_{Text2Time} \neq \mu_{Game1Time} \neq \mu_{Game2Time} \neq \mu_{FinalTime}$

H_0: $\mu_{Text1Time} = \mu_{Text2Time} = \mu_{Game1Time} = \mu_{Game2Time} = \mu_{FinalTime}$

H_1: Participants' perception of time in retrospect is influenced by their emotional state and cognitive load.

H_0: Participants' perception of time in retrospect is not influenced by their emotional state and cognitive load.

Research design

The current research study has a quantitative, quasi-experimental design (Shadish et al., 2001). A within-subjects design was used implying that each participant will be in both experimental and control conditions (Gravetter & Forzano, 2009). The within-subjects design allows the researcher to have a smaller sample size, seeing as how using the eye tracking equipment limits the researcher to one participant per data collection session. The difficulties of using the eye tracker are discussed in the section on the measurement instruments.

Validity of research design. In general, a quasi-experimental design aims to test the hypothesis about variables that can be manipulated in an experimental or laboratory setting, but without random assignment of participants (Shadish et al., 2001). The differentiating factor between quasi-experimental and experimental designs is that there is no random assignment of participants to experimental and control conditions. As discussed in the previous section, the present research manipulates emotion and cognitive load to draw conclusions about the impact on time perception. As a consequence of reasons explicated in the literature review, the researcher selected a quasi-experimental design to maximise the amount of usable scores from the small study population by deliberately sampling for participants of a certain age and to control for the potential impact of gender.

This lack of random assignment comes at a cost of certain threats to the validity of the present research. These threats are discussed in this section along with what the researcher has done to protect the research against the threats. Threats to the internal and statistical conclusion validity are discussed because these threats are concerned with the operations of the research and the relationship between treatment and outcome. Threats to the external and construct validity are discussed along with how these threats are expected to impact on the generalizability of the research outcomes.

Threats to internal validity. The internal validity of the study refers to the extent to which a causal conclusion based on the findings of the study is warranted (Shadish et al., 2001). Three aspects of causality need to be present in order for a causal conclusion to be drawn. These are precedence of the cause before the effect, the covariation of the cause and the effect, and that no other explanation must be able to clarify the relationship between cause and effect. In the case of the present research, this is to say that the two independent variables – emotion and cognitive load – must coexist, precede and explain the alteration in the dependent variable: time perception.

A threat to the internal validity of the study is the fact that once participants are required to make a duration judgement, they may become attentive to time and effectively alter the paradigmatic point of departure for the study from retrospective to prospective (Brown, 2010). The current threat to internal validity is referred to as testing effects. In other words, answering the question of how much time has passed once could influence responses when answering the question on subsequent occasions (Shadish et al., 2001). As discussed in more detail in a later section, the difference between the two paradigms is participants' awareness or attentiveness to the passage of time. Answering the question related to how much time participants think have gone by while completing the first task, may make them attentive to timing during the second task, influencing their time perception when completing the subsequent tasks. This artefact of the study could be a potential threat to the internal validity of the study.

Shadish et al. (2001) recommend that increasing the time between testing could reduce the additive effect of testing. However, for the present research, this is not a practical solution because participants are likely to get tired and their eyes become fatigued if they use the eye tracking equipment for too long. Removing the eye tracking equipment between tasks will require re-calibration of the equipment and previous experience with the equipment has taught the researcher that this is not always possible. Once the participant's eyes become fatigued, it becomes near impossible to calibrate the equipment. Furthermore, asking participants to come back after a week or so to complete a second task and then again to complete the third task is likely to lead to very high attrition rates. Considering that the sample population is quite small to begin with, this is not likely to be a viable option. Rather, the researcher asked the time perception questions for all the conditions at the end of the experiment, like Tobin and Grondin (2009) did in a study with a similar aim as the present research. Furthermore, the order of the tasks were varied for participants in an attempt to control for the possibility that the required duration estimate question might have on time perception of subsequent tasks.

The lack of randomized sampling inherent in quasi-experimental research designs can also be a threat to the internal validity of the study (Shadish et al., 2001). The random assignment of participants is said to eliminate selection biases, which means that any difference between groups must be due to chance and not systematic differences between the groups. The present study has some aspect of random assignment in that participants will not be selected to complete any one of the three experimental tasks in any particular order based on predetermined characteristics except for gender. However, complete random assignment of participants was not possible due to the fact that treatment groups had to be controlled for gender. As a consequence of the possible effect gender has on time perception, the researcher needs to control for the gender of subjects when assigning participants to the treatment groups.

Threats to statistical conclusion validity. Statistical conclusion validity concerns two related statistical inferences that affect the observed relationship of causal inferences. Firstly, whether the presumed cause and effect have any relationship and secondly, what the strength of this relationship is (Shadish et al., 2001). The first inference is classified along two types of errors. Type I error is when a researcher incorrectly confirms that a relationship between two variables exist in the sample when they do not exist in the population. Type II error is when the researcher incorrectly asserts that the relationship does not exist in the sample, when it in fact exists in the population. The second inference is related to the estimate of the strength of the relationship. For example, when a researcher concludes that a strong relationship exists in the sample, when in fact the relationship in the population is small or moderate at best. Statistical conclusion validity, therefore, relates to the accuracy of the conclusions drawn from the statistical analysis of research.

A key part of investigating the relationship between variables includes null hypothesis significance testing. This is to say that researchers test if the relationship between variables is zero or in other words, there is no relationship between the dependent and independent variables. As part of hypothesis testing, the researcher states what the probability is that the observed relationship occurred by chance in the study population. The relationship is then described as either statistically significant if the probability that the relationship occurs by chance is smaller than 5% ($p < .05$) or as not significant. The problem with this approach is that the researcher can accept the null hypothesis prematurely and the statistical significance say nothing about the effect size or the practical significance of the relationship (Shadish et al., 2001).

This section will explore threats to the statistical conclusion validity of the present study based on the introduction to null hypothesis significance testing. This is of relevance to the present study because the researcher will test the null hypothesis that positive emotion and cognitive load have no impact on time perception.

The first threat to statistical conclusion validity is low statistical power. This is when the outcomes of an experiment leads the researcher to infer that the relationship between dependent and independent variables is not significant (Shadish et al., 2001). Power in this instance refers to a statistical test's ability to detect relationships that exist in the study population (Cohen, 1988). This is to say that the researcher becomes more likely to commit the Type I error.

One of the ways to increase the power of a statistical test is to increase the sample size. The researcher is not able to do this because of the small study population. Tobin and Grondin (2009) argued that a sample of 16 participants is large enough for this kind of research experiment, but the resesarcher aimed to increase the sample size of the present research.

Another way to increase the power of a statisitcal test is to use a within-subjects design (Shadish et al., 2001). The researcher decided to implement a within-subjects design to maximise the responses from each participant and to increase the power of the statistical tests Gravetter & Forzano, 2009). There are specific problems that accompany a within-subjects design when studying time perception in the retrospective paradigm. This include that participants can become sensitized to timing if they are asked after every experimental condition to make a duration judgement. In order to avoid this, the researcher used the best practice which is to leave all the timing questions to the end of the questionnaire after all experimental conditions have been completed (Grondin, 2008).

Shadish et al., (2001) also recommend using homogenous participants to increase the power of statistical tests. For the present research, the researcher used a cohort sample of participants from a specific university, university department, on a similar academic level and of a similar age. This is a rather homogenous sample with only one key factor that differentiates participants that could potentially influence the treatment outcome and that is gender. The trade-off for a homogenous sample is that the study results are not likely to generalize well to the general population, but the researcher is willing to compromise this generalizability to increase the power of the tests and to avoid other pitfalls associated with a more heterogenous sample.

The second threat to statistical conclusion validity is the unreliability of measures. This is when an unreliable measurement instrument impacts the observed relationship between the dependent and independent variables (Shadish et al., 2001). Unreliability of measures can lead to both Type I and Type II errors because a measurement that cannot be repeated accurately can artificially create significant treatment effects when the actual relationship in the population is zero. It can also obscure a relationship that exists in the population because the scores are not reproducible.

The practical significance of an unreliable measure for the present research is important because the measurement instrument is a self-report questionnaire. Block and Zakay (2001), have found that retrospective duration judgements are unreliable. Participant scores vary significantly even when the same participants are tested under the same conditions but at different times. This effect, however, has also been observed when participants use other methods to estimate retrospective timing like reproduction.

Shadish et al. (2001), recommend increasing the number of measures by including more measurements or more measurement instruments. The present research does not lend itself to increasing the number of measurements because the within-subjects design already requires participants to make five duration judgements. Increasing this would make the overall participation considerably longer and then threats to internal validity like participant fatigue could start playing a role. Similarly, more measurement instruments would complicate the present research by including two or more techniques to measure time perception like estimation (self-report) and reproduction. As demonstrated by Block and Zakay (2001), this does not necessarily lead to better duration judgements as these different measures are still unreliable.

Related to this, unreliability of treatment implimentation is also considered a threat to statistical conclusion validity (Shadish et al., 2001). The researcher took additional steps to ensure that the experimental conditions for all participants were as near to exactly the same as possible. The researcher measured all participants in the same room using the same equipment and same furniture. The researcher read all the instructions in the same modulated tone and the lighting and ventilation are the same for all conditions. Pariticpants also participated during a short time span so that academic context like tests, projects or selection for future studies had a similar impact on all participants. Because the researcher administered all treatments personnally, the researcher knows about any deviations from the script or within the experiemntal conditions like a technical problem, which is reported in this report This third threat to statisitcal conclusion validity is of greater significance to field experiments, but it is worth noting that the artificial setting of the experimental conditions contributes to gaurding against the threat of unreliability of treatment implimentation.

The fourth and final threat to statistical conclusion validity is inacurate effect size estimation. This occurs when the size of the effect is measured poorly, according to Shadish et al. (2001). Including outliers or violating the assumptions of certain statistical tests can increase the likelihood of this threat to statisitcal conclusion validity. In order to protect against this threat, the researcher will test for outliers and trim the sample if neccesary (Field, 2009). Using the wrong kind of statistical test like for example, using parametric statistics when violating the assumptions of these tests will also likely lead to inaccurate effect size estimation. The researcher therefor will test for the assumptions of the desired statistical tests to protect against this.

With the small sample size of the present research, it is not likely that the scores will fall within the specified parameters of parametric statistical tests. It is more likely that a research will have to use non-parametric alternatives to avoid inaccurate effect size estimates. This can lead to an increased chance of Type II error, however, the alternative is to use the wrong statisitcal tests and to increase the likelihood of Type I error.

In concluding this section, the researcher identified four threats to the statistical conclusion validity of the present research. Protecting against the power of the statistical tests include increasing the sample size from the accepted 16 to 22, using a within-subjects design and using a homogenous sample. The second threat to statistical conclusion validity is the unreliability of measures, but the researcher is not able to include additional measures because these have been demonstrated to be similarly unreliable by Block and Zakay (2001). A smiliar threat to statistical conclusion validity in the unreliability of the treatment conditions, but using an experimental design helps to protect against this threat. The last identified threat is that of inaccurate effect size estimation. Testing for outliers and ensuring that the sample scores do not violate the assumptions of the statistical tests by using non-parametric tests protects the present research against inaccurate effect size estimations, but leads to an increased likelihood of Type II error.

Relationship between internal validity and statistical conclusion validity. Internal validity and statistical conclusion validity is related in that both are concerned with the operations of the research and the relationship between treatment and outcome (Shadish et al., 2001). This is to say that internal validity and statistical conclusion validity are related in its purpose to identify threats to the causal relationship between dependent and independent variables. It stands to reason that when the predicted relationship between the dependent and independent variables is accurately estimated by the researcher, it is still possible for the relationship to be unobservable statistically. In other words, the researcher can still commit Type II error. Conversely, the statistical analysis might prove that a relationship exist, but because the causal reasoning or postulation of the relationship is incorrect, the researcher might falsely assume that a covariance exists in the population. This is to say that Type I error occurs.

Testing effects and the lack of randomized sampling are threats to the internal validity of the present research that the researcher guards against by asking participants to make all their duration judgements at the end of all the testing conditions and controlling for key moderating variables when sampling. Similarly, the researcher increased the sample size, used a within-subjects design and selected a homogenous sample to protect against low statistical power. The researcher does not include additional measures to protect against the unreliability of measures, because the literature does not demonstrate increased reliability for the different measures of time perception. The researcher tests for outliers and other assumptions of parametric statistics to ensure that inaccurate effect size estimates are not made.

All things considered, the researcher is more likely to make a Type II error in the present research because of the trade-offs made in the design of the experiment to increase the internal and statistical conclusion validity. The researcher accepts that this might be the case and will revisit this point when writing up the findings of the present research.

Threats to external validity. The external validity of a study refers to the extent to which the causal inferences of the study hold true for other situations. Other situations can include other persons, settings, and other treatment conditions (Shadish et al., 2001). This is to say, will the effect on the dependent variable be observed when other people with different characteristics to the study sample in a different setting than the one in the experiment or under different treatment conditions still hold true?

External validity generally refers to the extent to which research findings will generalise to other people, contexts or treatments. These generalisations can take several forms including, generalisations from narrow to broad, broad to narrow and at the same level. A generalisation from narrow to broad refers to generalising from the sample to the greater population. Generalising from broad to narrow occurs when findings also hold true for individuals within the sample or population. Additionally, a generalisation could be at the same level, in other words, for other samples drawn from the same population. Consequently, external validity pertains to those persons, settings or treatment conditions not studied in the experiment.

In the present research, purposive sampling was used to ensure a balance of gender in the small sample. This allows the researcher to test the possible interaction effect gender could have on the relationship between the two independent variables and time perception. The researcher has taken great care to control for the most significant moderating variables, however, it was not possible to control for all moderating variables and as such, the external validity might be brought into question to some extent. Random samples, by their very nature, tend to be better suited to circumvent threats to external validity.

Threats to construct validity. Construct validity refers to making inferences based on research about the underlying constructs that the tested measures represent (Shadish et al., 2001). This is to say that the researchers do not necessarily study directly what they are interested in, but use indirect measures that represent those concepts (constructs) to study and draw inferences about those concepts. All factors that could result in a researcher making an inference about the concept they studied without being assured of what that concept actually represents, are considered threats to construct validity.

In order to increase construct validity, it is important to clearly define the people, treatment, or condition the construct represents. Also, only cases that accurately represent those constructs should be included in the research. In addition, the match between the representation and the underlying construct should be tested for any "slippage" (Shadish et al., 2001, p. 66). Finally, construct definitions should be revised accordingly. This essentially means there are two aspects to construct validity, namely, properly defining the characteristics or prototypical features of the construct, and using good assessment techniques that measure those features in totality and not anything else.

The first threat to construct validity is an inadequate explication of the constructs being researched (Shadish et al., 2001). Poorly defining what is included in the construct and what falls outside the construct could lead to the researcher drawing conclusions about an operational definition that does not really represent the construct underlying it. The researcher addressed this in the literature review section of this report where each variable under investigation was defined, and in the methodology section of the report where the researcher operationalises these definitions.

The second key threat to construct validity is reactive self-report changes. Self-report scores can be affected by participants' motivation to be part of the research (Shadish et al., 2001). The present research uses self-report measures extensively to measure constructs like emotion, cognitive load and time perception.

The researcher is aware that participants can adapt their responses to the self-report measures by giving answers they think the researcher expects or guessing what the true purpose behind the research is and responding accordingly. Both of these artefacts of social research could potentially play a role in the present research and the researcher is aware that self-report measures are increasingly vulnerable to this kind of threat to construct validity.

Brown (2008) and Wittmann (2009) report that self-report is one of the best ways to measure time perception as well as emotion because of the high internal validity associated with the measurement instrument. In addition, the researcher aims to augment self-report data for cognitive load with physiological data from an eye tracker. Augmenting self-report data with additional physiological measures helps to protect against reactive self-report changes.

Similarly, participants can be reactive to the experimental situation. This is to say that participants might not only actively try to respond in a way that they think is expected by the researcher, but the laboratory environment could lead participants to respond in ways that they normally would not. Participant scores then include reactivity to their environment and does not accurately represent the construct under investigation. In order to protect against this threat to construct validity, the design of the experiment is crucial. Making the variable under investigation less obvious can help participants in being less reactive. In the present research, the researcher informed participants that their pupil dilation is under investigation and not their time perception. This mild deception had three advantages. Firstly, it obscured the fact that time perception was under investigation which is crucial to studying the construct in the retrospective paradigm. Secondly, the researcher was able to motivate the use of the eye tracker that would otherwise have been conspicuous, and thirdly, it lessens participant's reactivity when making duration judgements.

In summary, three threats to construct validity are deemed of relevance to the present research. These include an inadequate explication of the constructs, reactive self-report changes, and reactivity to the experimental situation. The researcher defines the constructs under investigation in an exhaustive fashion in the literature review chapter and then also operationalises them later in this chapter. The researcher takes note of possible reactive behaviour and augments self-report scores – where possible – with physiological data. It is, however, noted that self-report is one of the best ways of studying the constructs under investigation and is an acceptable measurement instrument. Finally, the researcher uses a mild form of deception to avoid participants reacting to the experimental situation.

The relationship between external validity and construct validity. External validity and construct validity are complimentary in that both relate to generalisations of the research findings and valid knowledge about the construct under investigation shed light on the external validity of the research (Shadish et al., 2001). The knowledge gained from assessing valid constructs makes designing new experiments to investigate the same constructs easier because it helps to narrow the scope of what is applicable and what is not. In the present report, the researcher used other researchers' work and experience to design the present study because of the high construct validity demonstrated in their work.

Similarly, the researcher aims to further theoretical knowledge of time perception with the present research and to contribute to the understanding of psychological timing. Without being able to demonstrate that the present research measured the constructs under investigation accurately and that the results can generalize as a consequence of this, the research would not be able to fulfil its aim of furthering theoretical knowledge. Therefore, external and construct validity are essential to the present research.

Sampling

A relatively small sample size of approximately 16 participants will suffice based on previous research (Pan et al., 2007). A non-randomized quota sampling method will be used (Gravetter & Forzano, 2009), to obtain a sample of students with a quota for gender: Half male, half female. Furthermore, the participants must be of a similar age to avoid developmental or ageing effects confounding results.

Participants will be sampled from the University of Pretoria Psychology honours group. This will help to ensure that participants are between the required ages of 18 and 25 years and that they have a similar academic background and competency.

Participants for the present study were sampled from the University of Pretoria Psychology honours, MA Clinical Psychology and MA Research Psychology groups. This resulted in a study population of approximately 50 people. Students from these groups were selected based on their assumed level of academic literacy necessary to complete the reading tasks and their academic backgrounds as the low cognitive load reading task was a psychology text. Participants had to be fairly strong academically so that they would find the high cognitive load text difficult, but not impossible to read so that they will give up and only pretend to read the text. A certain level of academic proficiency is required to be accepted into the honours and masters groups as it involves a paper selection. The low cognitive load text was selected to be easy for the study population. Furthermore, participants had to be of a similar age or cohort between the ages of 21 and 40 (Brañas-Garza et al., 2007), as age can potentially influence time perception.

The class representatives of the various groups were contacted via email explaining the purpose of the study. The class representatives were then asked to promote the study to their class mates and record the contact details of all interested in participating. The researcher then sent an email to all the interested participants. Some class representatives preferred to give the researcher's contact details to all the members of the class and then have the interested people contact the researcher directly. The researcher only communicated via email with the potential participants. The researcher did not divulge any additional information about the purpose of the study other than adding the information sheet as an attachment to the email.

The researcher then made individual arrangements with each person that showed interest in participating. As many of the participants were classmates, data collection usually occurred before or after classes as these were the times that most students were available. The researcher contacted all people who showed interest and were able to arrange mutually agreeable time slots with all except one person. Some people did not show up for their agreed upon data collection sessions. These people were then contacted again to try and rearrange a more suitable time slot. In some cases, this was possible and an alternative arrangement was made. In other cases, however, people did not show up or reply to communications from the researcher. Under those circumstances, the researcher then removed the person's name from the list of interested participants.

In total, the researcher managed to secure 22 participants. Of these participants 27% were male (n = 6) and 73% were female (n = 16). The mean age of participants was 24.33 years with participants ranging from 21 to 40 years of age. The age of one participant was not recorded.

Measurement instruments

Two measurement instruments were used in the present research. These included the Grinbath EyeGuide eye tracker and a brief questionnaire. The eye tracker was used to obtain a physiological measure of cognitive load in the form of pupil dilation. The questionnaire used self-report to measure positive emotion, cognitive load and time perception. Other questions were added as manipulation checks to make sure that the participants noticed certain nuances of the game and actually read the provided texts.

Eye tracker. The Grinbath EyeGuide eye tracker was used as a physiological measure of cognitive load. The device was attached to participants' heads using an elastic headband. The eye tracker is a wireless system that uses a small infrared camera to track pupil movement and dilation. Each participant was fitted with the eye tracker and the instrument was then calibrated using the appropriate Grinbath EyeGuide computer programme. Calibration was sometimes a difficult process and could be time consuming. The eye tracker could be used over either the left or the right eye of participants depending on participants' preference. Furthermore, participants wearing glasses or contact lenses could also be fitted with this specific eye tracker (Grinbath, 2011). No participants who were fitted with the eye tracker wore glasses.

The infrared camera on the eye tracker broke early on in the study. Data collection sessions were then postponed in the hope that the researcher would be able to secure another device or have the device repaired. The researcher was not able to secure another device and repair of the broken device could not be completed in a timely manner. As such, there is not eye tracker data for the largest part of the sample. The methodology of the study stayed the same for all participants ($n_{\text{with eye tracker data}} = 7$; $n_{\text{without eye tracker data}} = 15$). When the eye tracker broke, the researcher continued to fit the device to all participants and pretended to calibrate it when it was not working. Participants did not notice that anything was wrong. In other words, all participants completed the same tasks and the same questionnaire was administered. Also, the same venue with the same lighting and ventilation conditions was used to ensure that these environmental artefacts of the study did not influence results.

Self-report questionnaire. After each task participants were asked to answer a couple of questions pertaining to the task they had just completed. The researcher administered the self-report questionnaire so that participants wearing the eye tracker device would not have to move their heads downward to fill in a pen and paper questionnaire. Administering the questionnaire by having the researcher read the questions had the added benefit that participants could not skip questions or answer the questions in a different order. This was particularly important as the questions related to participants' time perception were all administered after the final task. If a participant read these questions earlier on during the study they could start taking note of time and this would influence their time perception. Furthermore, the questions were not of a sensitive nature so the researcher did not expect participants to feel uncomfortable being asked and answering the questions.

The self-report questionnaire used Likert-type questions when asking participants to judge how much fun they had while completing the tasks (positive emotion) and how difficult the tasks were (cognitive load). Participant scores on emotion included rating themselves on a scale of one to 10 with, one being "not a lot of fun" and 10 being "a lot of fun". Similarly, participant scores on cognitive load included rating themselves on a scale of one to 10 with, one being "not difficult" and 10 being "very difficult".

For the questions related to time perception, participants were prompted to give the first response that came to mind and not try to reason out the answer with what sounded like the most logical time. Participants were also prompted to answer as accurately as possible and to respond "in minutes and second". The questionnaire is attached as Appendix A. The script with instructions to participants is attached as Appendix B.

Operationalization of constructs

An operational definition is a specification for measuring a construct (Gravetter & Forzano, 2009). In order to make sure that the researcher accurately and completely measures the constructs under investigation, the researcher operationalises the theoretical definitions of the constructs in a workable and measurable way. The operational definitions for the dependent variable time perception as well as the main independent variables cognitive load and emotion are described in the present section. Smaller independent variables that have been identified as moderators and that are actively controlled for, that is age and gender are also operationalised here.

Time perception. Time perception is operationalised as the duration a participant reports experiencing while completing a primary experimental task. This is measured in minutes and second on a self-report questionnaire.

Cognitive load. Cognitive load is operationalised as the difficulty a participant reports experiencing while completing a primary experimental task. This is measured on a scale of one to ten with one representing 'not difficult at all' and ten representing 'very difficult', on a self-report questionnaire.

Emotion. Emotion is operationalised as the affective state a participant reports experiencing while completing a primary experimental task. Emotion is measured on a scale of one to ten with one being 'no fun at all' and ten being 'a lot of fun', on a self-report questionnaire.

Age. Age is operationalised as the chronological age of participants measured in years on an open-ended self-report question.

Gender. Gender is operationalised as the psychological identification of participants to a specific group as either male or female. Gender is measured as a dichotomous response on a self-report questionnaire. The researcher would like to note that other operationalizations of gender also exist and the researcher accepts these to fall outside the scope of the present research.

Data collection procedures

Data collection was done in an empty office in the University of Pretoria Department of Psychology. The blinds of the room were drawn and the light was turned on to ensure that all data collection sessions occurred under the same lighting conditions as the amount of light that enters the eye is controlled by the iris and this could influence pupil dilation. Furthermore, participants were seated at a desk with a chair so that the computer screen would be at a comfortable height for most participants. The researcher was seated approximately 1m to the right of the participant. Data collection was done with each participant individually at a time agreed upon by the researcher and the participant.

Upon arrival, participants were given the information sheet to read and familiarise themselves with the purpose and potential risks and benefits related to participation. The information sheet was sent out prior to the session via email, but participants were requested to reread the sheet and encouraged to ask any questions before signing the informed consent form.

After signing the informed consent form, the participant was fitted with the eye tracking equipment. Thereafter, the eye tracker was calibrated. The participant was then told what the order of proceedings would be for the data collection session and once again the researcher reiterated that if the participant felt uncomfortable at any time or did not want to continue, they were allowed to stop the experiment and would be allowed to leave without incurring any kind of punishment or discrimination. The participant would then start the experiment.

Experimental and control tasks. All participants were given the exact same instructions for the experimental and control tasks as the researcher read the instructions off a script. The experiment consisted of a total of five tasks. The tasks were designed to manipulated cognitive low along two levels (high and low), and emotion along two levels (positive and neutral). The final task was the control task which comprised an empty interval.

The order of the experimental tasks was varied and participants partook in either 'experiment 1' or 'experiment 2'. Participants were not told that there was two versions of the experiment and participants were randomly assigned to either experiment. Experiment 1 had the reading tasks first, followed by the game tasks and then ended with the empty interval task. Experiment 2 had the game tasks first, followed by the reading tasks and ending in the control task. The high cognitive load condition was presented first every time and followed by the low cognitive load condition. The tables below illustrate the order of the tasks for the two groups as well as the manipulation of the independent variables induced by each task.

Table 1

Tasks for experimental conditions: Experiment 1

			Cognitive Load		
			High	Low	Neutral
Emotion	Neutral	Read text	Task 1	Task 2	
	Positive	Play video game	Task 3	Task 4	
	Neutral	Do nothing (control)			Task 5

Table 2

Tasks for experimental conditions: Experiment 2

			Cognitive Load		
			High	Low	Neutral
Emotion	Positive	Play video game	Task 1	Task 2	
	Neutral	Read text	Task 3	Task 4	
	Neutral	Do nothing (control)			Task 5

The reading texts were academic in nature. The high cognitive load text was an extract from Eldredge's (1971) "The allopatric model and phylogeny in paleozoic invertebrates". The text was selected based on the fact that it was a difficult subject matter the study population would not likely be familiar with written in an older, more formal academic style. The low cognitive load text was an extract from the first chapter of the University of Pretoria Department of Psychology's first year psychology textbook. The text was selected because it would be familiar subject matter for the study population and it was written in a less formal, more conversational style. Both texts were retyped in the same font and font size to ensure that typographical features of the texts would not make it easier or more difficult for participants to read. The texts were displayed on the computer screen as portable document formats (PDFs) using Adobe Acrobat software. The texts are attached as Appendix C.

The game tasks were a version of the free-ware arcade game Digger. The game is similar to Pacman, but somewhat less familiar. The game was chosen because it was fairly easy to play with few rules, making it easier for participants to familiarize themselves with the game.

It is also less popular making it less likely that participants had played the game prior to their participation in the experiment and avoiding testing effects (Babbie, 2005). The high cognitive load condition of the game was played first as participants would find the game more challenging at first and then become more comfortable with the game as they become more familiar with it after playing it a while. Furthermore, the high cognitive load condition was created playing the game at a higher level where the objects in the game moved at a faster pace. For the high cognitive load condition participants played the video game at level four of five and for the low cognitive load condition the game was played at level one of five. Tobin and Grondin (2009), used similar experimental tasks in their time perception study investigating the influence of emotion on time perception.

The final task for all participants was the control empty interval task. During this task, the participant was told to relax and look at the computer screen until the alarm goes off. Some participants found this task to be confusing and did not quite understand that they were not required to do anything.

The starting of the tasks were indicated by the words 'the task starts now', said by the researcher. The researcher then started the timer to countdown the exact interval. Participants were told, 'when the alarm goes off, you should stop immediately as it indicates the end of the task'. The same sensory modality had to be used to indicate the start and end of the interval as using different modalities like audio and visual, could influence time perception (Boltz, 2005). The researcher decided on an auditory queue as the researcher could not programme the software to deliver a timed visual queue.

After the fifth task (control empty interval) participants were asked to estimate the durations of each task in the same order as the tasks were completed. This method to study retrospective time perception for a within-subjects study has been used by various researchers (Boltz, 2005; Brown & Stubbs, 1988; Grondin & Plourde, 2007; Tobin & Grondin, 2009).

Data Analysis

After data collection, all participant responses are captured by hand for the purpose of statistical analysis. The researcher created a data set in International Business Machines' (IBM) Statistical Program for the Social Sciences (SPSS) version 20. The data set contains basic demographic information for each participant and their responses to the items on the self-report questionnaire that was administered by the researcher during data collection. Each participant was awarded an identification number to distinguish their unique responses from those of other participants.

During data analysis, the researcher uses descriptive statistics like frequency distributions to describe participant responses to each of the items on the questionnaire. Non-parametric correlation coefficients are used to determine the relationship between the independent and dependent variables. The researcher selected Spearman's rank order coefficient (Spearman's rho) as the correlation test of choice because the small sample size does not satisfy the stringent requirements of parametric tests like Pearson's correlation coefficient (Pallant, 2010).

Chapter 4: Statistical analysis and results

The present chapter deals with the statistical analysis of participant scores from the present research. The chapter will start by testing for the normal distribution of participant scores and consequently deciding on the applicability of the use of parametric statistics. In the small sample, the use of parametric statistics is likely to be limited and the researcher will explore the use of non-parametric alternatives where appropriate. In addition, the chapter explores the data by describing the sample and through the use of descriptive statistics like frequency distributions.

The chapter also includes looking for correlations in the data by analysing the impact of the two independent variables (emotion and cognitive load) under the various test conditions (i.e. positive and neutral emotion, high and low cognitive load) on the dependent variable of time perception. The researcher suspects that a positive correlation will exist between increased cognitive load and time perception, in other words, as cognitive load increases, duration judgements will increase. Contrary to this, the researcher suspects a negative correlation between positive emotion and time perception so to say that when positive emotion increase, duration judgements will decrease. It is the difficult game task (Game1) that is of specific interest to the researcher as the literature predicts a paradoxical effect under the conditions of high cognitive load and positive emotion. The statistical analysis through use of correlations for this experimental condition is expected to help the researcher accept or reject the test hypothesis.

The present chapter also contains an extensive discussion of the findings of the various statistical analyses. Despite this being an unconventional approach, the researcher decided to include the analyses and discussions in one chapter to provide a better logical flow to the overall discussion. The chapter ends in a summary of the statistical analysis which then leads to the next chapter which is the conclusion of the present research including a discussion of the findings and the limitations inherent to the present research.

Testing for normality

Many statistical techniques assume that the distribution of scores on the dependent variable is normal (Pallant, 2010). Normality describes the circumstances when participant scores on the dependent variable present as a symmetrical, bell-shaped curve with the most scores in the middle and fewer scores toward the ends of the bell. Testing for normality is crucial because parametric statistics requires data to fall into one of several distributions that statisticians have described in the past. If participant scores on the dependent variable do not conform to this catalogue of distributions, parametric test are likely to present inaccurate results (Field, 2009).

The Kolmogorov-Smirnov test for normality (K-S test) compares participant scores to a normally distributed set of scores with the same mean and standard deviation (Lilliefors, 1967). In other words, the test is used to check scores from the present research against what scores would look like if the set was normally distributed and had the same mean and standard deviation. A significant score ($p < 0.05$) illustrates that there is a statistically significant difference between participant scores and a normal distribution. In other words, a significant result on the K-S test implies that participant scores violate the assumptions of normality and scores are not normally distributed. The implication of this is that non-parametric statistics need to be used during the statistical analysis to avoid inaccurate results.

Table 3

Tests for normality

	Kolmogorov-Smirnov[a]		
	Statistic	df	Sig.
Text1Time	.264	22	.000
Text2Time	.266	22	.000

Game1Time	.236	22	.002
Game2Time	.249	22	.001
FinalTime	.152	22	.200*

Note: *. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Table 3 shows the results of the K-S test for participant scores on the dependent variable of time perception for the complete sample (N = 22). The table indicates that scores for all tasks except the control task violate the assumption of normality. Participant scores for FinalTime (time perception on the final control task) are not significantly different from a normal distribution with the same mean and standard deviation ($P = 0.2$; $p \leq 0.05$). Participant scores for time perception on the hard reading task (Text1Time) are considered not to be normally distributed ($p \leq 0.05$). Time perception scores for the easy reading task (Text2Time) are not normally distributed ($p \leq 0.05$). Time perception scores for the difficult game task (Game1Time) are not normally distributed ($p \leq 0.05$). Similarly, participant scores for the easy game task (Game2Time) are not normally distributed according to the K-S test ($p \leq 0.05$).

The results of the K-S test indicate that participant scores are not normally distributed for all the experimental tasks. When analysing the scores for the dependent variable of time perception for the experimental tasks, the researcher will have to use non-parametric statistics in order to get accurate results. Furthermore, the small sample size further limits the applicability of parametric statistics when analysing the data of the present research.

Description of sample

This section of the chapter explores the sample by checking for possible outliers and looking at the distributions of scores for the independent variables of gender and age. Frequency distributions are used where appropriate to describe the study sample and non-parametric correlations in the form of Spearman's rho are used to explore the relationship between the independent variables that relate to the demographics of the sample to their perception of time. The researcher also looks at the scores for the answers to the cover questions to report on participants' understanding of the present research and their voluntary participation. This was of interest to the researcher to see if there could exist any difference between participants who said they understood the study and participants who asked questions about the study on their time perception. This does not form part of the primary hypothesis testing and consequently is reported on in this section of the chapter which aims at describing the sample.

Checking for outliers

The final sample of the present research was N = 22. Of this sample, one participant was considered a possible outlier because the participant overestimated the durations for the difficult and easy game tasks very substantially. For example, on the difficult game task (Game1), the participant in question estimated the duration of the task to be 07:00, when in fact it was 02:00. This participant's scores were tested to see if they can statistically be considered as outliers. According to Field (2009), outliers can be dealt with in one of three primary ways which include trimming or cutting the score, transforming the score or changing the score.

Firstly, it is recommended that the researcher double check the accuracy of the data to make sure it was not entered into the data set incorrectly or that the score is possible within the universe of responses (Levin & Fox, 2011). The researcher checked both of these assumptions and confirmed that the score was possible within the universe of responses and the score was accurately entered into the data set. This leaves the researcher to conclude that the participant score in question was indeed accurate and not due to any error on the researcher's part.

Secondly, the researcher calculated the standard score (z-score) for the participant in question (ID = 107) on the tasks where the participant's scores were considered far out. This was for the difficult game task (Game1Time) and the easy game task (Game2Time).

$$z_{Game1Time\ ID107} = \frac{X_{Game1Time} - \bar{X}_{Game1Time}}{S_{Game1Time}}$$

$$z_{Game1Time\ ID107} = \frac{(7 - 2.78)}{1.56}$$

$$z_{Game1Time\ ID107} = 2.70$$

For time perception of the difficult game task (Game1Time) participant ID = 107 z-score for was $z_{Game1time\ ID107}$ = 2.70 which means that the participant score fell close to three standard deviations above the mean. This means that if the data for participant scores of time perception for the difficult game task was normally distributed, then 99.65% of participants would score on or below that of participant ID = 107. Statistically, this participant score is considered an outlier with a standard score greater than 2.50 ($z > 2.50$) (Levin & Fox, 2011).

Next, the researcher calculated the z-score for time perception of the easy game task (Game2Time) for participant ID = 107:

$$z_{Game2Time\ ID107} = \frac{X_{Game2Time} - \bar{X}_{Game2Time}}{S_{Game2Time}}$$

$$z_{Game2Time\ ID107} = \frac{(7 - 2.91)}{1.40}$$

$$z_{Game2Time\ ID107} = 2.91$$

For time perception of the easy game task (Game2Time) participant ID = 107 had a z-score of $z_{Game2time\ ID107}$ = 2.91 which means that the participant fell within three standard deviations of the mean. This is to say that if the data for time perception scores on the easy game task was normally distributed, 99,82% of participants would score on or below that of participant ID = 107. This participant is statistically considered an outlier with a standard score that is greater than two and a half standard deviations above the mean (z > 2.50) (Levin & Fox, 2011). The researcher used the same methods to calculate the standard scores for participant ID = 107 time perception on the other experimental tasks and concluded that the scores where within the acceptable range at $z_{\text{Text1Time ID107}} = 1.64$ and $z_{\text{Text2Time ID107}} = 1.67$. The researcher also checked individual participant scores for all four the experimental tasks and the control task to ensure that no other potential outliers were present. This was not the case (Field, 2009).

In addition to calculating the standard scores for participant ID = 107, the researcher decided to look at the difference in the means as well as range and maximum scores for time perception on the experimental and control tasks between the full sample of N = 22 and the trimmed sample N = 21. The two tables below contain the analysis results from the full sample and the trimmed sample.

Table 4

Descriptive statistics of time perception: Full sample

		Text1Time	Text2Time	Game1Time	Game2Time	FinalTime
N	Valid	22	22	22	22	22
	Missing	0	0	0	0	0
Mean		00:02:47	00:02:47	00:02:47	00:02:55	00:02:17
Median		00:02:00	00:02:00	00:02:00	00:02:37	00:02:15
Mode		00:02:00	00:02:00	00:02:00	00:02:00	00:02:00
Std. Deviation		00:01:21	00:01:20	00:01:34	00:01:24	00:00:55
Skewness		.803	.576	1.155	1.600	.120
Std. Error of Skewness		.491	.491	.491	.491	.491
Kurtosis		-.600	-1.150	.812	2.464	-.574
Std. Error of Kurtosis		.953	.953	.953	.953	.953
Range		00:04:40	00:04:10	00:06:00	00:05:30	00:03:00
Minimum		00:00:50	00:00:50	00:01:00	00:01:30	00:01:00
Maximum		00:05:30	00:05:00	00:07:00	00:07:00	00:04:00

Table 5

Descriptive statistics of time perception: Trimmed sample

		Text1Time	Text2Time	Game1Time	Game2Time	FinalTime
N	Valid	21	21	21	21	21
	Missing	0	0	0	0	0
Mean		00:02:40	00:02:40	00:02:35	00:02:43	00:02:17
Median		00:02:00	00:02:00	00:02:00	00:02:30	00:02:30
Mode		00:02:00	00:02:00	00:02:00	00:02:00	0:01:00[a]
Std. Deviation		00:01:17	00:01:16	00:01:18	00:01:06	00:00:56
Skewness		.970	.689	.832	1.321	.073
Std. Error of Skewness		.501	.501	.501	.501	.501
Kurtosis		-.052	-.880	-.502	1.657	-.680
Std. Error of Kurtosis		.972	.972	.972	.972	.972
Range		00:04:40	00:04:10	00:04:00	00:04:10	00:03:00
Minimum		00:00:50	00:00:50	00:01:00	00:01:30	00:01:00
Maximum		00:05:30	00:05:00	00:05:00	00:05:40	00:04:00

Note: [a]Multiple modes exist. The smallest value is shown.

The mean time perception on all tasks except the control task increase when comparing the full sample to the trimmed sample by a minimum of 00:07 (Text1, Text2) and a maximum of 00:12 (Game 1, Game 2). This is to say that with the full sample (N = 22) the mean time perception was $\bar{X}_{\text{Text1Time}}$ = 02:47 and in the trimmed sample the mean was $\bar{X}_{\text{Text1Time}}$ = 02:40. The same figures were recorded for the easy reading task: $\bar{X}_{\text{Text2Time}}$ = 02:47 (N = 22) changed to $\bar{X}_{\text{Text2Time}}$ = 02:40 (N = 21). Similarly, the mean time perception scores for the difficult game task went from $\bar{X}_{\text{Game1Time}}$ = 02:47 (N = 22) to $\bar{X}_{\text{Game1Time}}$ = 02:35 (N = 21). For the easy game task, the difference in mean time perception scores was even more pronounced and went from $\bar{X}_{\text{Game2Time}}$ = 02:55 (N = 22) to $\bar{X}_{\text{Game2Time}}$ = 02:43 (N = 21). The mean time perception for the control task stayed exactly the same with both the full sample $\bar{X}_{\text{FinalTime}}$ = 02:17 (N = 22) and the trimmed sample $\bar{X}_{\text{FinalTime}}$ = 02:17 (N = 21).

The researcher draws two conclusions from looking at the ways the mean time perception scores changed from the full sample to the trimmed sample. Firstly, the mean time perception scores in the trimmed sample were closer to the objective time of 02:00. According to Grondin (2010), the literature predicts that time perception will be altered as a consequence of the effects of the independent variables positive emotion and high cognitive load. This is to say that on average, some deviation from the objective time is expected, but participants should be able to estimate an interval of two minutes with fair accuracy (Block et al., 2010). The mean time perception scores that are closest to the objective time are therefore expected to be the most accurate reflection of the population's ability to estimate time to some level of accuracy.

Secondly, the researcher noted that the mean scores on the game tasks (both the difficult and hard game tasks) where affected the most by excluding the outlier participant (ID = 107). These where the tasks were the participant in question gave the most outlandish duration judgements that were more than two and a half standard deviations from the mean ($z > 2.5$; $z_{Game1Time\ ID107} = 2.705$; $z_{Game2Time\ ID107} = 2.917$).

In addition, the range for time perception for the difficult game task changes considerably from $R_{Game1Time}$ = 06:00 (N = 22) to $R_{Game1Time}$ = 04:00 (N = 21). The range for time perception on the easy game task (Game2Time) changes from $R_{Game2Time}$ = 05:30 (N = 22) to $R_{Game2Time}$ = 04:10 (N = 21). Block and Zakay (1997) found that duration judgements in the retrospective paradigm tend to have a greater range than duration judgements of the same length made in the prospecitve paradigm. This is to say that it can be expected that the range for time perception will be greater in the present study, however, clear outliers do not need to be included during the statisitcal analysis of the present research.

After calculating the standard scores for participant ID = 107 and comparing the distribution of participant scores with specific reference to the means, ranges and maximum scores for time perception on both the difficult and easy game tasks (Game1Time and Game2Time), the researcher decided to trim participant ID = 107 scores on both tasks from the statistical analysis.

Distribution of gender. The study sample analysed in this section consist of a total of 22 participants (N = 22) for the analysis of scores on the dependent variable time perception for the difficult and easy reading tasks (Text1Time and Text2Time) and well as the control task (FinalTime) and 21 participants (N = 21) for the two game tasks. The full sample consists of six males and 16 females compared to the same number of males and only 15 females in the trimmed sample.

Table 6

Frequency distribution of gender: Full sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	6	27.3	27.3	27.3
	Female	16	72.7	72.7	100.0
	Total	22	100.0	100.0	

According to table 6 for the full sample (N = 22), 6 or approximately 27% are males and 16 or approximately 73% are females.

Table 7

Frequency distribution of gender: Trimmed sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	6	28.6	28.6	28.6
	Female	15	71.4	71.4	100.0
	Total	21	100.0	100.0	

According to table 7 the trimmed sample (N = 21) consisted of 6 or approximately 29% males and 15 or approximately 71% females. The researcher aimed to sample half males and half females, but was unable to achieve this equal split. The effect of gender on time perception is not one that can simply be ignored, despite contradictory findings being published in the literature (Block et al., 2010). The researcher will examine the differences in time perception between the genders to see if the present research will cast any light on the contradictory nature of findings in the literature. This will be discussed in greater detail later in the chapter.

Gender differences for time perception. The researcher wanted to know if there were any statistically significant differences between males and females for time perception as gender was identified as a possible moderating variable in the literature (Espinosa-Fernandéz et al., 2003). A Mann-Whitney U Test is used to test for statistical differences between the two independent groups (Pallant, 2010).

Table 8

Test for statistical differences between time perception for all conditions

	Text1Time	Text2Time	Game1Time	Game2Time	FinalTime
Mann-Whitney U	46.000	46.000	42.500	42.500	29.500
Z	-.150	-.149	-.197	-.198	-1.231
Asymp. Sig. (2-tailed)	.881	.881	.844	.843	.218
Exact Sig. [2*(1-tailed Sig.)]	.914[b]	.914[b]	.850[b]	.850[b]	.235[b]

Note: [b]Not corrected for ties.

Table 8 shows the outputs from the Mann-Whitney U Test and demonstrates that all probability values are greater than .05 ($p \leq .05$) which means that there are no significant differences in time perception score between males and females under any of the experimental or control conditions. The researcher consequently fails to find any support from the present research to indicate gender differences in time perception.

Distribution of age.

Table 9

Descriptive statistics of age: Full sample

		Age
N	Valid	21
	Missing	1
Mean		24.33
Median		23.00
Mode		22
Std. Deviation		4.187
Skewness		2.821
Std. Error of Skewness		.501
Kurtosis		9.915
Std. Error of Kurtosis		.972
Range		19
Minimum		21
Maximum		40

Table 9 describes the mean age of the full sample (N = 22) as $\bar{X}_{Age}$ = 24 years and four months, with a mode of 22 years (Mo = 22). This is to say that most of the participants were aged 22 years but as the consequence of including one older participant, the mean age was pushed slightly upward to over 24 years. The range was 19 (R_{Age} = 19) with a minimum age of 21 years and a maximum age of 40 years. The positive skewness indicates that the participants' age is clustered around the lower end of the scale. There was one participant aged 40 years and the other participants where all in their low to mid-twenties. The researcher decided not to remove the participant aged 40 years from the sample used for statistical analysis because the literature indicated that this age was not likely to influence time perception (Block et al., 1999). Positive kurtosis indicated a leptokurtic distribution in the sample. This was desirable and expected as the researcher attempted to gain a cohort sample to minimise the possible impact that age could have on time perception.

Table 10

Descriptive statistics of age: Trimmed sample

		Age
N	Valid	20
	Missing	1
Mean		24.50
Median		23.00
Mode		22
Std. Deviation		4.224
Skewness		2.805
Std. Error of Skewness		.512
Kurtosis		9.738
Std. Error of Kurtosis		.992
Range		19
Minimum		21
Maximum		40

The mean age of the trimmed sample (N = 21) was $\bar{X}_{Age}$ = 24 years and 6 months, the mode was 22 years, which implies that 22 years was the age that occurred the most. The range was 19 with a minimum age of 21 years and a maximum age of 40 years. The age distribution in both samples looked similar with only a slight difference in mean age. The impact of the one older participant was greater in the trimmed sample moving the mean age on by two months. This was a small difference and the researcher did not consider it to have a considerable impact on the quality of the sample considering that the means age and both minimum and maximum ages of participants still fell within the cohort limits recommended by Block et al., (1997).

The literature does not predict any correlation between age and time perception, but rather identified age as a potential confounding variable. The researcher reports here on the relationship between the age of the participants and their time in the table below.

Table 11

Relationship between participant age and time perception

			Age
Spearman's rho	Text1Time	Correlation Coefficient	-.183
		Sig. (2-tailed)	.426
		N	21
	Text2Time	Correlation Coefficient	-.194
		Sig. (2-tailed)	.399
		N	21
	Game1Time	Correlation Coefficient	.050
		Sig. (2-tailed)	.831
		N	21
	Game2Time	Correlation Coefficient	.078
		Sig. (2-tailed)	.738
		N	21
	FinalTime	Correlation Coefficient	-.006
		Sig. (2-tailed)	.978
		N	21

Table 11 demonstrates that there are only weak correlations between age and time perception. The sample included all 22 participants, but one participant's age was not recorded. None of the correlations appear to be of statistical significance. Hence, the researcher accepts that age did not have a systematic effect on the dependent variable and consequently accepts what the literature predicts in terms of no linear relationship between age and time perception (Brañas-Garza et al., 2007). The researcher did not exclude any participants based on their age.

Answers to cover questions. In this section of the chapter, the researcher reports on participants' answers to the questions asked prior to commencement of the study. The purpose is to illustrate that the researcher explained the present study to participants and ensured that participants understood the process and what was expected and not expected of them. This also gave participants the opportunity to ask the researcher any questions if they were unclear about the study or any potential impact the study and its procedures could have on the individuals.

An example of the questionnaire used by the researcher is attached as Appendix A. All participants answered in the affirmative to the following question prior to commencing with the experimental tasks:

Cover question 1: Did you read the information sheet?

Cover question 2: Did you understand the information sheet?

Cover question 3: Did you sign an informed consent form?

Table 12

Frequency distribution of participant responses to cover question 1

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	22	100.0	100.0	100.0

Table 13

Frequency distribution of participant responses to cover question 2

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	22	100.0	100.0	100.0

Table 14

Frequency distribution of participant responses to cover question 3

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	22	100.0	100.0	100.0

Two participants had a question before commencing with the study and the researcher deviated from the script to answer their questions. This was the final question on the cover of the response sheet:

Cover question 4: Do you have any questions before we begin?

Table 15

Frequency distribution of participant responses to cover question 4

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	2	9.1	9.1	9.1
	No	20	90.9	90.9	100.0
	Total	22	100.0	100.0	

Of the two participants who answered 'yes' to cover question 4 which asked whether they had any questions prior to commencing with the study, one participant wanted to know what the impact of the eye tracker would be on their sensitive eyes. The researcher assured the participant that there was no reason to believe that the eye tracker would cause any harm to the participant, but if the participant felt any discomfort at any point during the study, they were welcome to stop the process with no retribution or any negative consequences to the participant as a result of ceasing participation. The second participant wanted to know if they would be finished in time for their next class which was due to start in 30 minutes. The researcher responded that the total time to complete the experiment will not be more than 30 minutes. This was also the participant who is considered the outlier (ID = 107). This made the researcher question even further the validity of the participant in question's responses and reinforced the researcher's decision to trim this participant's responses from the statistical analysis instead of transforming or changing their scores.

With the exception of one participant not giving their age, captured data from the eye tracker and the question 'which task felt the longest?', all participants (N = 22) responded to all questions. The question regarding the task that felt the longest was added later by the researcher after sampling a few participants and noticing contradictory responses from some participants. It was added as a manipulation check, unfortunately, it was added late in the data collection phase and only 10 participants where asked and responded to the question. There are no 'missing values' in the analysed data set outside of the exceptions mentioned and the eye tracker data. This leaves the researcher with a relatively complete data set for the self-report questionnaire to analyse. This was the expected advantage of having the participants respond to the self-report questionnaire by having the researcher ask the questions in a systematic way and then recording participants' responses.

Description and analysis of time perception scores

The researcher now turns to the descriptive analysis of participants' responses for time perception as displayed in table 4 and table 5 earlier in this chapter. When looking at the modes for time perception of the experimental tasks, table 5 shows that the most frequent response from the participants in the present research was an accurate duration judgement. The mode was 02:00 (with the exception of FinalTime for the trimmed sample N = 21 which was 01:00), which is exactly the same as the objective time of the task. Examining the mean duration judgements paints a slightly different picture with the means on all tasks exceeding the objective time. The means for all duration judgements were somewhat greater than the objective time, but the control task mean was the closest and most accurate at 02:17 for both the full sample (N = 22) and the trimmed sample (N = 21).

The distributions of all time perception scores were positively skewed. This indicates that participant responses clustered around the lower end of the scale. Kurtosis figures, on the other hand, indicate a platykurtic distribution in most cases (Text1, Text2, Game1, Final). The big recorded ranges for all tasks (MR_{Text1} = 0:04:40, MR_{Text2} = 0:04:10, MR_{Game1} = 0:04:00, MR_{Game2} = 0:04:10, MR_{Final} = 0:03:00) demonstrate the large number of participants at the tails end of the distribution. When taking the mean, mode, skewness, kurtosis and range into account, it is evident that participant duration judgements were clustered toward the lower end of the scale near the objective time of 02:00 with a few participants clear outliers toward the high end of the scale.

The duration of the easy game task (Game2Time; positive emotion, low cognitive load) was overestimated the most at $\bar{X}_{Game2Time} = 02{:}43$. This links up with the question posed to some participants: Which of the tasks felt the longest? Of the 10 participants who were asked which task felt the longest, three responded that Game2 felt the longest. Along with Game2, Text1 and the control task (final task) where considered to be the longest. The researcher thought this strange because the control task, on average ($\bar{X}_{FinalTime} = 02{:}17$), was estimated as the shortest task. Unfortunately, the researcher did not anticipate a contradiction like this and only realised after sampling a few participants that responses were contradictory at times. This is why only 11 participants were asked this question in the hope that it would parallel their perceived times. Of the 11 participants who were asked the question, one include participant ID = 107 who responded that the control task felt the longest despite giving the shortest duration judgement for the control task of all the tasks ($FinalTime_{ID107}$ = 02:00).

Table 16

Frequency distribution of participant responses to the question 'which tasks felt the longest?': Full sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All the same	1	4.5	9.1	9.1
	Text1	3	13.6	27.3	36.4
	Game2	3	13.6	27.3	63.6
	Final	4	18.2	36.4	100.0
	Total	11	50.0	100.0	
Missing	System	11	50.0		
Total		22	100.0		

Table 17

Frequency distribution of participant responses to the question 'which tasks felt the longest?': Trimmed sample

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All the same	1	4.8	10.0	10.0
	Text1	3	14.3	30.0	40.0
	Game2	3	14.3	30.0	70.0
	Final	3	14.3	30.0	100.0
	Total	10	47.6	100.0	
Missing	System	11	52.4		
Total		21	100.0		

Of the participants who responded that Game2 felt the longest, it was interesting to observe a medium negative correlation rho = -0.5 between positive emotion and time perception. This would seem to indicate that these participants did not consider the task to be fun and it felt the longest. It must be noted that only three participants responded that Game2 felt the longest, so the researcher does not draw any significant conclusions from this. It is merely an interesting observation and worth exploring in future research.

Table 18

Relationship between time perception and positive emotion and cognitive load for participants who responded that Game2 felt the longest

			Game2Time
Spearman's rho	Game2Fun	Correlation Coefficient	-.500
		Sig. (2-tailed)	.667
		N	3
	Game2Difficulty	Correlation Coefficient	.000
		Sig. (2-tailed)	1.000
		N	3

Of the participants who responded that Text1 (high cognitive load, neutral emotion) felt the longest, there was also a moderate negative correlation between positive emotion and time perception (rho = -0.5). Once again, it is noted that only three participants from the total sample responded that Text1 felt the longest and as a consequence, the researcher does not draw any inferences from the statistical analysis, it is worth nothing and an interesting observation that might be worth exploring in future studies.

Table 19

Relationship between time perception and positive emotion and cognitive load for participants who responded that Text1 felt the longest

			Text1Time
Spearman's rho	Text1Fun	Correlation Coefficient	-.500
		Sig. (2-tailed)	.667
		N	3
	Text1Difficulty	Correlation Coefficient	1.000**
		Sig. (2-tailed)	.
		N	3

Note: **Correlation is significant at the 0.01 level (2-tailed).

Furthermore, when analysing the correlation between positive emotion and time perception for participants who responded that the final task seemed the longest, there was a perfect positive correlation (rho = 1), which was considered statistically significant. Again, it must be noted that only three participants considered the control task (final task) to be the longest, the researcher does not draw any inferences from this small sub-sample.

Table 20

Relationship between time perception and positive emotion and cognitive load for participants who responded that the control task (final) felt the longest

			FinalTime
Spearman's rho	FinalFun	Correlation Coefficient	1.000**
		Sig. (2-tailed)	.
		N	3
	FinalDifficulty	Correlation Coefficient	-.500
		Sig. (2-tailed)	.667
		N	3

Note: ** Correlation is significant at the 0.01 level (2-tailed).

In trying to explain this, the researcher notes that the participant rated the task very low for positive emotion (see table 21 below). Rating the task low on positive emotion corresponds to findings from other time perception studies where positive emotion was positively correlated with shorter durations and a lack of positive emotion was correlated with longer duration estimates (Droit-Volet & Gil, 2009).

Table 21

Frequency distribution of positive emotion for participants who responded that the control task (final) felt the longest

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (no fun)	1	33.3	33.3	33.3
	2	1	33.3	33.3	66.7
	3	1	33.3	33.3	100.0
	10 (a lot of fun)	0	0	0	
	Total	3	100.0	100.0	

It is interesting and worth noting that six out of nine participants who identified one task feeling longer than any of the other tasks, there was a negative correlation between positive emotion and time perception. This is to say that the less fun a task was perceived to be, the longer it felt. Despite the very weak evidence in the present research as a consequence of a small sample, this finding is in accordance with the spirit of the time in time perception research that argues that less fun tasks are considered longer than fun tasks (Droit-Volet & Gil, 2009).

Descriptive statistics and correlations for experimental tasks

For each of the five tasks, the researcher first describes the responses to the self-report questionnaire with the use of descriptive statistics. Of relevance will be the mean, mode, range, minimum and maximum values for each experimental task and the manipulated variables. These variables are emotion and cognitive load with the dependent variable being time perception.

It is worth reminding the reader at this point that the researcher used self-report manipulation checks to make sure that the independent variables of emotion and cognitive load were in fact altered. The researcher devised a simple questionnaire which required participants to rate the amount of fun they had while completing the task on a Likert-type scale. The lowest possible score was 1 and it indicated 'no fun at all'. The highest possible score was 10 and it indicated 'a lot of fun'. Similarly, participants were asked to report on the task difficulty by rating the task on a Likert-type scale from one to 10. A score of one was considered 'not difficult at all' and the maximum score of 10 was considered 'very difficult'. The researcher deliberately kept the questionnaire simple as explained earlier on because this was merely a manipulation check and not a psychometric evaluation of either emotional states or cognitive load.

The researcher uses Spearman's rho to correlate the responses of the self-report questionnaire pertaining to the conditions of emotion ('how much fun did you have?') and cognitive load ('how difficult was the task?'), with time perception ('how much time passed while you were playing the game/reading the text?'). As described in chapter three on methodology, Spearman's rho was selected because of the small sample size; furthermore, the resultant data did not satisfy the assumptions of normality as demonstrated earlier on in the present chapter. Using the parametric alternative (Pearson's r) to correlate the data would likely yield inaccurate results (Field, 2009).

Herewith follows the statistical analysis for each of the five tasks the participants completed. The analysis is in the same order as the experiment was conducted and first looks at the two reading tasks (first difficult then easy) and is then followed by the two game tasks (first difficult, then easy), and the section ends with the analysis from the control task which was also the final task of the experiment.

Text1: High cognitive load, neutral emotion

Descriptive statistics.

Table 22

Descriptive statistics for Text1 (difficult reading task)

		Text1Fun	Text1Difficulty	Text1Time
N	Valid	22	22	22
	Missing	0	0	0
Mean		2.86	7.18	00:02:47
Median		2.00	8.00	00:02:00
Mode		1	8	00:02:00
Std. Deviation		2.100	1.918	00:01:21
Skewness		.707	-.551	.803
Std. Error of Skewness		.491	.491	.491
Kurtosis		-1.072	-.687	-.600
Std. Error of Kurtosis		.953	.953	.953
Range		6	6	00:04:40
Minimum		1	4	00:00:50
Maximum		7	10	00:05:30

The full sample of N = 22 was used to analyse the scores on the difficult reading task (Text1). There are 22 participants who completed responses to the first reading task (Text1). Of these participants, the mean self-report score for positive emotion was $\bar{X}_{\text{Text1Fun}} = 2.86$ out of a possible maximum of 10. Participants were required to respond on a Likert-type scale with 0 being 'no fun at all' and 10 being 'a lot of fun'. The mode was $\text{Mo}_{\text{Text1Fun}} = 1$ which means that the score that was recorded most often was the lowest possible score indicating the task was 'no fun at all'. Skewness for fun was positive and participants were clustered around the lower end of the scale. The measures of central tendency along with skewness indicate that participants did not consider the difficult reading task a fun task and consequently, it stands to reason that the task evoked a neutral emotional response in participants. This was the desired outcome of the researcher.

The mean difficulty self-report score was $\bar{X}_{\text{Text1Difficulty}} = 7.18$. Once again a Likert-type scale was used where 0 was considered 'not difficult at all' and 10 was considered 'very difficult'. Most participants scored Text1 8/10 on difficulty ($\text{Mo}_{\text{Text1Difficulty}} = 8$), indicating that it was most probably a high cognitive load task. No participants rated the difficult reading task to be lower than 4 on the self-report Likert-type scale. Skewness for task difficulty was negative and indicates that most of the participants were clustered around the high end of the scale, supporting the conclusion that the task induced high cognitive load. This was what the researcher expected. In other words, the manipulation checks for positive emotion and high cognitive load indicated that the difficult reading task did in fact induce a neutral emotional state as well as high cognitive load.

The average duration judgement for the difficult reading task was $\bar{X}_{\text{Text1Time}}$ 02:47. This was a slight overestimate of the duration of the task that was in fact only 02:00 in objective time. The longest duration judgement was 05:30 and the shortest was 00:50. The range is quite large at $R_{\text{Text1Time}} = 04{:}40$. Skewness for time perception was positive, indicating that participants' responses clustered around the lower end of the scale. That is to say that most participants considered the task to feel shorter than the mean of 02:47.

Table 23

Frequency distributions of time perception on Text1 (difficult reading task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	00:00:50	1	4.5	4.5	4.5
	00:01:30	2	9.1	9.1	13.6
	00:01:40	1	4.5	4.5	18.2
	00:01:50	1	4.5	4.5	22.7
	00:02:00	7	31.8	31.8	54.5
	00:02:30	1	4.5	4.5	59.1
	00:03:00	3	13.6	13.6	72.7
	00:04:00	2	9.1	9.1	81.8
	00:05:00	3	13.6	13.6	95.5
	00:05:30	1	4.5	4.5	100.0
	Total	22	100.0	100.0	

Table 23 shows that 32% of participants accurately estimated the time for the difficult reading task. The task was a high cognitive load, neutral emotion condition and it was expected that participants would overestimate duration judgements under high cognitive load conditions (Block et al., 2010). Ten participants (45%) overestimated the time for Text1, compared to five participants (22%) who underestimated the interval. This is to say that participants were more likely to overestimate the length of the interval for the difficult reading task which was in line with the findings of Grondin (2010), who's review of the literature indicated that time perception increased as cognitive load increased.

Table 24

Frequency distributions of positive emotion for Text1 (difficult reading task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (no fun)	9	40.9	40.9	40.9
	2	4	18.2	18.2	59.1
	3	1	4.5	4.5	63.6
	4	2	9.1	9.1	72.7
	5	2	9.1	9.1	81.8
	6	3	13.6	13.6	95.5
	7	1	4.5	4.5	100.0
	10 (a lot of fun)	0	0	0	
	Total	22	100.0	100.0	

Table 24 demonstrates that most participants did not find the difficult reading task fun. On the self-report Likert-type scale, the research considers the scores 1-5 as 'not fun' and 6-10 as 'fun'. Eighteen of the participants (82%) considered Text1 to be 'not fun'. This manipulation check confirmed the researcher's expectations that the difficult reading task would be a neutral emotion condition.

Table 25

Frequency distributions of cognitive load for Text1 (difficult reading task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0 (not difficult)	0	0	0	0
	4	4	18.2	18.2	18.2
	5	1	4.5	4.5	22.7
	6	1	4.5	4.5	27.3
	7	4	18.2	18.2	45.5
	8	7	31.8	31.8	77.3
	9	3	13.6	13.6	90.9
	10 (very difficult)	2	9.1	9.1	100.0
	Total	22	100.0	100.0	

Table 25 shows the frequency of participant scores on the self-report question related to task difficulty. The researcher considers scores of 1-5 as 'not difficult' and 6-10 as 'difficult'. Of the sample, only five participants (23%) rated Text1 as not difficult. The other 17 participants scored Text1 in the range of 'difficult' (77%). The manipulation check confirms the researcher's expectation that Text1 was a difficult task and induced a high cognitive load condition.

From the above analysis, the researcher concludes that Text1 – as reported by participants – was a high cognitive load, neutral emotion task. Under these circumstances the literature predicts overestimates of duration judgements (Grondin, 2010), as a positive correlation exists between cognitive load and time perception. Of the sampled participants, 45% overestimated the task length.

Correlation.

Table 26

Relationship between time perception and positive emotion and cognitive load (Text1)

					Text1Time
Spearman's rho	Text1Fun	Correlation Coefficient			-.238
		Sig. (2-tailed)			.285
		N			22
		Bootstrap[c]	Bias		.017
			Std. Error		.225
			95% Confidence Interval	Lower	-.633
				Upper	.264
	Text1Difficulty	Correlation Coefficient			.410
		Sig. (2-tailed)			.058
		N			22
		Bootstrap[c]	Bias		-.003
			Std. Error		.194
			95% Confidence Interval	Lower	-.025
				Upper	.734

Note: **Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

[c]Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples.

Table 26 shows the correlation between positive emotion (Text1Fun) and time perception (Text1Time), as well as high cognitive load (Text1Difficulty) and time perception (Text1Time) for the difficult reading task. The relationship between positive emotion and time perception, as well as the relationship between high cognitive load and time perception was investigated using Spearman's rank order correlation. There was a weak, negative correlation between positive emotion and time perception, r = -.238, n = 22, $p < 0.05$, with positive emotion being associated with decreased duration judgements. The correlation was not considered statistically significant and the percentage of variance was calculated to be 6%. This indicates that only 6% of the variance in time perception scores can be attributed to the impact of positive emotion. When looking at the bootstrapped confidence intervals the upper and lower levels cross zero which means that the population value could be zero or in other words, the relationship witnessed in the sample could fall outside 95% of scores seem in the population. Furthermore, the bootstrapped confidence interval also implies that the direction of the relationship in the population is not guaranteed with the current sample and it could in fact work in the opposite direction (Field, 2013).

There was a moderate, positive correlation between high cognitive load and time perception, $r = .410$, $n = 22$, $p < 0.05$, indicating that increased cognitive load is associated with increased duration judgements. The correlation was considered statistically significant and the percentage of variance was calculated to be 17%. Similar to the relationship between positive emotion and time perception on the difficult reading task, the bootstrapped confidence interval of the relationship between cognitive load and time perception crosses the zero, which means that the sampled scores fall outside of 95% of the probably scores in the population and the direction of the relationship is not guaranteed (Field, 2013).

Effect size. The effect size was calculated comparing scores on time perception for the difficult reading task to that of the control task. The calculations for Cohen's d are shown below. The effect size $d_{Text1Time} = 0.43$ is considered small (Cohen, 1988).

$$d = \frac{\overline{X_{Text1Time}} - \overline{X_{FinalTime}}}{\sqrt{\frac{{SD_{Text1Time}}^2 + {SD_{FinalTime}}^2}{2}}}$$

$$d = \frac{2.78 - 2.28}{\sqrt{\frac{(1.35^2) + (0.93^2)}{2}}}$$

$$d = 0.43$$

The researcher concludes that under the experimental conditions created with Text1, participants' time perception was influenced by the high cognitive load they experienced in that their duration judgements increased. Under these same conditions, participants' time perception was influenced by the positive emotions they experienced in that their duration judgements decreased. However, the bootstrapped confidence interval indicates that neither the relationship between positive emotion and time perception, nor the relationship between cognitive load and time perception is likely to be found within 95% of the population scores. In other words, the observed relationships are so rare that they might in fact operation in the opposite direction in the study population.

Testing for differences. The researcher is interested in seeing if there are differences between time perception scores on the difficult reading task when compared to the control task. In order to test for these differences, the researcher will use a Wilcoxon Signed Rank Test which is designed to measure differences when participants are tested under two different conditions (Pallant, 2010).

Table 27

Difference for time perception between Text1 and the control task

	FinalTime — Text1Time
Z	-1.252[a]
Asymp. Sig. (2-tailed)	.211

Note: [a]Based on positive ranks.

The Wilcoxon Signed Rant Test revealed that there are no statistically significant differences between participant scores on time perception between the difficult reading task and the control task (z = -1.25; p < .05).

Effect size. The effect size was calculated for the difference between scores on time perception for the difficult reading task to that of the control task. The calculations are shown below. The effect size $r_{Text1Time}$ = .19 is considered small (Cohen, 1988).

$$r_{Text1Time} = \frac{z}{\sqrt{N}}$$

$$r_{Text1Time} = \frac{1.25}{\sqrt{44}}$$

$r_{Text1Time} = .19$

In concluding this section, a small negative relationship was noted between positive emotion and time perception which was in-line with the literature (Droit-Volet & Gil, 2009). A moderate positive relationship is noted between cognitive load and time perception which is also in-line with what the literature predicts (Block et al., 2010). The observed relationships has a small effect size and the difference between participant scores under the high cognitive load, neutral emotion condition and the control conditions are not significant.

Text2: Low cognitive load, neutral emotion

Descriptive statistics.

Table 28

Descriptive statistics for Text2 (easy reading task)

		Text2Fun	Text2Difficulty	Text2Time
N	Valid	22	22	22
	Missing	0	0	0
Mean		6.23	1.64	00:02:47
Median		6.00	1.00	00:02:00
Mode		6[a]	1	00:02:00
Std. Deviation		1.541	1.399	00:01:20
Skewness		-.762	3.136	.576
Std. Error of Skewness		.491	.491	.491
Kurtosis		1.511	10.784	-1.150
Std. Error of Kurtosis		.953	.953	.953
Range		7	6	00:04:10
Minimum		2	1	00:00:50
Maximum		9	7	00:05:00

Note: [a]Multiple modes exist. The smallest value is shown.

The full sample (N = 22) was used to analyse participant scores from the easy reading task (Text2). Table 28 shows the frequency distributions for participant scores for the easy reading task on the variables of emotion (Text2Fun), cognitive load (Text2Difficulty) and time perception (Text2Time).

The mean self-report score for positive emotion was $\bar{X}_{Text2Fun}$ = 6.23 out of a possible maximum of 10. Participants were required to respond on a Likert-type scale with 0 being 'no fun at all' and 10 being 'a lot of fun'. The mode was $Mo_{Text2Fun}$ = 6 which means that the score that was recorded most often was toward the higher end of the scale. Skewness for positive emotion (Text2Fun) was negative and participants were clustered around the higher end of the scale. The measures of central tendency along with skewness indicate that participants considered the easy reading task a fun task and consequently, it stands to reason that the task evoked a positive emotional response in participants.

This was not the desired outcome as the task was designed to be a neutral emotion condition. The researcher notes that as a consequence of this, the expected impact on time perception has to be adapted according to the literature which predicts that there is a negative relationship between emotion and time perception (Droit-Volet & Meck, 2007). In other words, the researcher initially expected participant scores on the easy reading task to be fairly accurate with minimal influence of emotion (neutral emotion) and cognitive load (low cognitive load). As a consequence of the manipulation check and the findings that participants considered the easy reading to task to be fun (i.e. positive emotion, low cognitive load) the researcher adapts their expectations to see a negative relationship between emotion and time perception.

The mean difficulty self-report score was $\bar{X}_{Text2Difficulty}$ = 1.64. Once again a Likert-type scale was used where 0 was considered 'not difficult at all' and 10 was considered 'very difficult'. Most participants scored Text2 1/10 on difficulty ($Mo_{Text2Difficulty}$ = 1), indicating that it was most probably a low cognitive load task. No participants rated the easy reading task to be higher than 7 on the self-report Likert-type scale. Skewness for task difficulty was positive and indicates that most of the participants were clustered around the low end of the scale, supporting the conclusion that the task induced low cognitive load. This was what the researcher expected as the task was designed to be a low cognitive load task.

The average duration judgement for the easy reading task was $\bar{X}_{Text2Time}$ 02:47. This was a slight overestimate of the duration of the task that was in fact only 02:00 in objective time. The longest duration judgement was 05:00 and the shortest was 00:50. The range is quite large at $R_{Text2Time}$ = 04:10. Skewness for time perception was positive, indicating that participants' responses clustered around the lower end of the scale. That is to say that most participants considered the task to feel shorter than the mean of 02:47, in fact the score that was recorded most was exactly two minutes ($Mo_{Text2Time}$ = 02:00).

To examine the distribution of participant scores for the three variables in question, the researcher now turns to frequency distributions for each of the variables individually. Starting with time perception (Text2Time), then looking at emotion (Text2Fun) and lastly reporting on cognitive load (Text2Difficulty).

Table 29

Frequency distributions of time perception for Text2 (easy reading task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	00:00:50	1	4.5	4.5	4.5
	00:01:30	3	13.6	13.6	18.2
	00:01:45	1	4.5	4.5	22.7
	00:01:50	1	4.5	4.5	27.3
	00:02:00	6	27.3	27.3	54.5
	00:02:30	1	4.5	4.5	59.1
	00:03:00	2	9.1	9.1	68.2
	00:04:00	2	9.1	9.1	77.3
	00:04:20	1	4.5	4.5	81.8
	00:04:30	1	4.5	4.5	86.4
	00:05:00	3	13.6	13.6	100.0
	Total	22	100.0	100.0	

Table 29 shows that 27% (n = 6) of participants accurately estimated the time for the easy reading task (Text2Time). Text2 was designed to be a low cognitive load, neutral emotion condition. Further on, participants' responses to the task being fun or not will be discussed, but it is worth mentioning here that participants considered Text2 to be generally enjoyable. The positive emotion condition was expected to result in underestimates. Only six participants (27%) underestimated the duration of Text2, compared to 10 (45%) overestimates. This is contradictory to the literature, which argues that under positive emotion conditions, participants are more likely to underestimate the time that has passed while completing another task (Droit-Volet & Meck, 2007).

Table 30

Frequency distributions of positive emotion for Text2 (easy reading task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (No fun)	0	0	0	0
	2	1	4.5	4.5	4.5
	4	1	4.5	4.5	9.1
	5	4	18.2	18.2	27.3
	6	6	27.3	27.3	54.5
	7	6	27.3	27.3	81.8
	8	3	13.6	13.6	95.5
	9	1	4.5	4.5	100.0
	10 (A lot of fun)	0	0	0	100.0
	Total	22	100.0	100.0	

Table 30 shows the frequency of participants' responses to the self-report question of how much fun they had while completing Text2. As mentioned earlier, on the self-report Likert-type scale, the researcher considers the scores 1-5 as 'not fun' and 6-10 as 'fun'. 27% (n = 6) of participants considered Text2 as 'not fun' compared to 73% (n = 16) of participants who considered the task 'fun'. The manipulation check reveals that the participants enjoyed reading the text on psychology, which the researcher did not expect. The researcher expected an easy psychology text to evoke a neutral emotional response in participants. According to Block et al. (2010), a positive emotion, low cognitive load task should lead to underestimates of intervals. The effect of positive emotion is expected to be in the same direction as low cognitive load and consequently, under these circumstances the researcher would expect a clear underestimation of the task interval as well as a positive correlation between positive emotion and time perception, as well as a negative correlation between cognitive load and time perception.

Table 31

Frequency distributions of cognitive load for Text2 (easy reading task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (Not difficult)	15	68.2	68.2	68.2
	2	5	22.7	22.7	90.9
	4	1	4.5	4.5	95.5
	7	1	4.5	4.5	100.0
	10 (Very difficult)	0	0	0	100.0
	Total	22	100.0	100.0	

Table 31 shows the frequency of participant responses on the self-report question related to the difficulty of the easy reading task (Text2Difficulty). The researcher considers scores of 1-5 as 'not difficult' and 6-10 as 'difficult'. As is evidenced in table 30, 96% of participant scores can be categorised as 'not difficult'. Only one participant considered Text2 to be a difficult task. This was in-line with what the researcher expected for this task as it was designed to be an easy reading task. The selected text was an extract from an introductory psychology textbook. It was written in simple language and it was a subject matter that participants were familiar with considering that they were sampled from the psychology department of their university.

Examining the scores on the self-report questionnaire that formed part of the manipulation check, the researcher now adjusts their expectations regarding the relationship between time perception and the two independent variables. Initially, the easy reading task was designed to evoke a neutral emotional state under low cognitive load which the literature predicts would result in underestimates of time perception (Block et al., 2010). The researcher now notes that according to the results from the manipulation checks that the easy reading task evoked a positive emotional state under low cognitive load. There should be a clear negative relationship between the independent and dependent variables. This relationship will be investigated in the following section.

Correlation.

Table 32

Relationship between time perception and positive emotion and cognitive load (Text2)

					Text2Time
Spearman's rho	Text2Fun	Correlation Coefficient			.480*
		Sig. (2-tailed)			.024
		N			22
		Bootstrap[c]	Bias		-.006
			Std. Error		.183
			95% Confidence Interval	Lower	.069
				Upper	.788
	Text2Difficulty	Correlation Coefficient			-.040
		Sig. (2-tailed)			.861
		N			22
		Bootstrap[c]	Bias		.002
			Std. Error		.192
			95% Confidence Interval	Lower	-.381
				Upper	.358

Note: *Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

[c]Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples.

Table 32 shows the correlation between positive emotion (Text2Fun) and time perception (Text2Time), as well as cognitive load (Text2Difficulty) and time perception (Text2Time). The relationship between positive emotion and time perception, as well as the relationship between cognitive load and time perception was investigated using Spearman's rho for reasons mentioned earlier on in this chapter. There was a moderate, positive correlation between positive emotion and time perception, $r = .480$, $n = 22$, $p > 0.05$, with positive emotion being associated with increased duration judgements. The correlation was considered statistically significant and the percentage of variance was calculated to be 23%. When looking at the bootstrapped confidence intervals, the upper and lower levels do not cross zero. This is important because it means that the researcher is 95% confident that the relationship between positive emotion and time perception reported under the conditions of Text2 is representative of the study population. This output demonstrates that there is a genuine effect in the population (Field, 2013).

There was a weak, negative correlation between cognitive load and time perception, r = -.040, n = 22, $p > 0.05$, indicating that increased cognitive load was loosely but inversely associated with increased duration judgements. The correlation was not considered statistically significant and the percentage of variance was calculated to be only .16%. The bootstrapped confidence interval crosses zero which means that participant scores from the study sample represent only 5% of the study population. The implication of this is that the observed relationship between cognitive load and positive emotion might not really exist or it might operate in the opposite direction (Field, 2013).

Effect size. To investigate the effect size, Cohen's d was calculated:

$$d = \frac{\overline{X_{Text2Time}} - \overline{X_{FinalTime}}}{\sqrt{\frac{{SD_{Text2Time}}^2 + {SD_{FinalTime}}^2}{2}}}$$

$$d = \frac{2.78 - 2.28}{\sqrt{\frac{(1.33^2) + (0.93^2)}{2}}}$$

$$d = 0.43$$

The effect size for time perception under the positive emotion low cognitive load condition participants reported for the easy reading task is d = 0.43, which is considered small (Cohen, 1988). This is the same calculated effect size for the difficult reading task.

Testing for differences. The researcher is interested in seeing if there are differences between time perception scores on the easy reading task and the control task. In order to test for these differences, the researcher will use a Wilcoxon Signed Rank Test which is designed to measure differences when participants are tested under two different conditions (Pallant, 2010).

Table 33

Difference for time perception between Text2 and the control task

	FinalTime — Text2Time
Z	-1.484[a]
Asymp. Sig. (2-tailed)	.138

Note: [a]Based on positive ranks.

The Wilcoxon Signed Rant Test revealed that there are no statistically significant differences between participant scores on time perception between the difficult reading task and the control task ($z = -1.48$; $p < .05$).

Effect size. The effect size was calculated for the difference between scores on time perception for the difficult reading task to that of the control task. The calculations are shown below. The effect size $r_{Text1Time}$ = .22 is considered small (Cohen, 1988).

$$r_{Text1Time} = \frac{z}{\sqrt{N}}$$

$$r_{Text1Time} = \frac{1.48}{\sqrt{44}}$$

$$r_{Text1Time} = .22$$

Concluding this section, in total, 54% of participants were able to estimate the duration of the easy reading task either accurately or as somewhat lower than the objective time. This leads the researcher to accept that for the easy reading task, positive emotion – as reported by participants – under low cognitive load conditions resulted in under estimations of time perception. This is in-line with what the literature predicts as Block et al. (2010) noted that cognitive load and time perception is positively correlated. However, Droit-Volet and Meck (2007) noted that emotion and time perception is *negatively* correlated.

The important thing to note is that the effect size of the combined impact of emotion and cognitive load on time perception was very small. For both the reading tasks, the researcher demonstrates a positive relationship between emotion and time perception as well as a negative relationship between cognitive load and time perception. However, the bootstrapped confidence interval demonstrates that the relationship between cognitive load and time perception is not representative of the study population. On the other hand, the researcher is confident that in 95% of cases the relationship between emotion and time perception will move in the same direction as the reported relationship for the present sample.

In other words, the observed relationship between positive emotion and time perception contradicts what the literature predicts, but the relationship is moderately strong and of statistical significance.

Game1: High cognitive load, positive emotion

For the game tasks, the researcher excluded the responses from one participant as the participant was demonstrated to be an outlier regarding their duration judgements for both the difficult and easy game tasks. The following section contains the analysis of 21 participant responses. The section contains descriptive statistics including frequency distributions for the two main independent variables under investigation including emotion (Game1Fun) and cognitive load (Game1Difficulty), as well as the dependent variable time perception (Game1Time). The section also contains an investigation of the relationship between these variables and the effect size of the relationship.

Descriptive statistics.

Table 34

Descriptive statistics for Game1 (difficult game task)

		Game1Fun	Game1Difficulty	Game1Time
N	Valid	21	21	21
	Missing	0	0	0
Mean		7.00	4.90	00:02:35
Median		7.00	5.00	00:02:00
Mode		8	4[a]	00:02:00
Std. Deviation		1.732	1.640	00:01:18
Skewness		-.255	-.283	.832
Std. Error of Skewness		.501	.501	.501
Kurtosis		.184	-.201	-.502
Std. Error of Kurtosis		.972	.972	.972
Range		7	6	00:04:00
Minimum		3	2	00:01:00
Maximum		10	8	00:05:00

Note: [a]Multiple modes exist. The smallest value is shown.

The trimmed sample (N = 21) was used to analyse participant scores from the difficult game task (Game1). Table 34 shows the frequency distributions for participant scores for the difficult game task on the variables of emotion (Game1Fun), cognitive load (Game1Difficulty), and time perception (Game1Time).

The mean self-report score for emotion was $\bar{X}_{\text{Game1Fun}} = 7.00$ out of a possible maximum of 10. Participants were required to respond on a Likert-type scale with 0 being 'no fun at all' and 10 being 'a lot of fun'. The mode was $Mo_{\text{Game1Fun}} = 7$ which means that the score that was recorded most often was toward the higher end of the scale. Skewness for emotion (Game1Fun) was negative and participants were clustered around the higher end of the scale. The measures of central tendency along with skewness indicate that participants considered the difficult game task a fun task and consequently, it stands to reason that the task evoked a positive emotional response in participants. This was the desired outcome of the difficult game task as it was expected to evoke a positive emotional state.

The mean difficulty self-report score was $\bar{X}_{Game1Difficulty}$ = 4.9. Once again a Likert-type scale was used where 0 was considered 'not difficult at all' and 10 was considered 'very difficult'. Most participants scored Game1 4/10 on difficulty ($Mo_{Game1Difficulty}$ = 4), however, it is noted that more than one mode exists. The frequency distribution table that follows later in this section will demonstrate that scores of five and six were reported the same amount of times as the lowest mode of four. When looking at the minimum and maximum scores reported for cognitive load, it is evident that participants did not want to select scores at the extreme ends of the scale and scores ranged from two to eight. Skewness for task difficulty was negative and indicates that most of the participants were clustered around the high end of the scale, supporting the conclusion that the task induced high cognitive load. This was what the researcher expected as the task was designed to be a high cognitive load task.

The average duration judgement for the difficult game task was $\bar{X}_{Game1Time}$ 02:35. This was a slight overestimate of the duration of the task that was in fact only 02:00 in objective time. The longest duration judgement was 05:00 and the shortest was 01:00. The range is not that large and the lowest reported thus far at $R_{Game1Time}$ = 04:00. Skewness for time perception was positive, indicating that participants' responses clustered around the lower end of the scale. That is to say that most participants considered the task to feel shorter than the mean of 02:35, in fact the score that was recorded most was exactly two minutes ($Mo_{Game1Time}$ = 02:00).

To examine the distribution of participant scores for the three variables in question, the researcher now turns to frequency distributions for each of the variables individually. Starting with time perception (Game1Time), then looking at emotion (Game1Fun) and lastly reporting on cognitive load (Game1Difficulty).

Table 35

Frequency distributions of time perception for Game1 (difficult game task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	00:01:00	2	9.5	9.5	9.5
	00:01:30	4	19.0	19.0	28.6
	00:01:50	1	4.8	4.8	33.3
	00:02:00	5	23.8	23.8	57.1
	00:02:30	1	4.8	4.8	61.9
	00:03:00	3	14.3	14.3	76.2
	00:04:00	2	9.5	9.5	85.7
	00:05:00	3	14.3	14.3	100.0
	Total	21	100.0	100.0	

Table 35 shows that 24% (n = 5) of participants accurately estimated the time for Game1. Game1 was a high cognitive load, positive emotion condition. This is the experimental task that was of most importance to the researcher as the literature predicted a paradoxical effect: high cognitive load is expected to increase duration judgements, whereas positive emotions are expected to result in underestimated duration judgements. Seven participants (33%) underestimated the interval, compared to nine participants (43%) who overestimated the interval.

Table 36

Frequency distributions of positive emotion for Game1 (difficult game task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (Not fun)	0	0.0	0.0	0.0
	3	1	4.8	4.8	4.8
	5	3	14.3	14.3	19.0
	6	4	19.0	19.0	38.1
	7	4	19.0	19.0	57.1
	8	6	28.6	28.6	85.7
	9	1	4.8	4.8	90.5
	10 (A lot of fun)	2	9.5	9.5	100.0
	Total	21	100.0	100.0	

Table 36 shows the frequency distribution of participants' responses to the self-report question of how much fun they had while completing Game1. As mentioned earlier, on the self-report Likert-type scale, the researcher considers the scores 1-5 as 'not fun' and 6-10 as 'fun'. Most participants considered Game1 to be a 'fun' task with 81% (n = 17) of participants scoring Game1 six or higher, compared to 19% (n = 4) who scored Game1 five or less. The manipulation check indicates that Game1 created a positive emotion condition as expected by the researcher.

Table 37

Frequency distributions of cognitive load for Game1 (difficult game task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (Not difficult)	1	0.0	0.0	0.0
	2	3	14.3	14.3	14.3
	4	5	23.8	23.8	38.1
	5	5	23.8	23.8	61.9
	6	5	23.8	23.8	85.7
	7	2	9.5	9.5	95.2
	8	1	4.8	4.8	100.0
	10 (Very difficult)	0	0.0	0.0	100.0
	Total	21	100.0	100.0	

Table 37 shows the frequency of participant responses on the self-report question related to the difficulty of Game1. The researcher considers scores of 1-5 as 'not difficult' and 6-10 as 'difficult'. As is evidenced in table 37, 38% of participants (n = 8) regarded Game1 as 'difficult' compared to 62% (n = 13) who rated Game1 as 'not difficult'.

Examining the scores on the self-report questionnaire, the researcher concludes that the manipulation was successful and that the difficult game task evoked a positive emotional state under high cognitive load conditions. The researcher would have liked to see a clearer distinction in task difficulty reported by participants for the difficult game task when compared to other tasks. After completing the second game task (easy game task Game2), participants where asked if the second game task was easier than the first. The table below show their responses:

Table 38

Frequency distribution for question 'Was the second game task easier than the first game task?'

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	21	100.0	100.0	100.0
	No	0	0.0	0.0	100.0
	Total	21	100.0	100.0	

Table 38 demonstrates that all participants in the trimmed sample (N = 21) considered the second game task to be easier than the first game task. This is not conclusive evidence, but taken into account along with the self-report scores on cognitive load for the difficult game task, the researcher accepts that Game1 was a high cognitive load condition.

This is the experimental condition that is of particular interest to the researcher as the literature predicts a paradoxical effect when participants are required to make duration judgements in the retrospective paradigm when they are in a positive emotional state under high cognitive load (Block et al., 2010; Droit-Volet & Meck, 2007; Grondin, 2007; Wittman, 2009).

Correlation.

Table 39

Relationship between time perception and positive emotion and cognitive load (Game1)

					Game1Time
Spearman's rho	Game1Fun	Correlation Coefficient			-.177
		Sig. (2-tailed)			.442
		N			21
		Bootstrap[c]	Bias		.022
			Std. Error		.228
			95% Confidence Interval	Lower	-.563

			Upper	.297
Game1Difficulty	Correlation Coefficient			-.154
	Sig. (2-tailed)			.504
	N			21
	Bootstrap[c]	Bias		.003
		Std. Error		.243
		95% Confidence Interval	Lower	-.603
			Upper	.345

Note: **Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

[c]Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples.

Table 39 shows the correlation between positive emotion (Game1Fun) and time perception (Game1Time), as well as high cognitive load (Game1Difficulty) and time perception (Game1Time). The relationship between positive emotion and time perception, as well as the relationship between high cognitive load and time perception was investigated using Spearman's rank order correlation. There was a weak, negative correlation between positive emotion and time perception, $r = -.177$, n = 21, p > 0.05, with positive emotion being associated with decreased duration judgements. This was in-line with the literature that predicts when positive emotion increases, duration judgements will decrease (Hancock & Block, 2012). The correlation was not considered statistically significant and the percentage of variance was calculated to be 3%. This is to say that only 3% of the variance in time perception is attributed to the impact of positive emotion. When looking at the bootstrapped confidence intervals the upper and lower levels cross zero which means that the population value could be zero or in other words, the relationship witnessed in the sample could fall outside 95% of scores seem in the population. This is to say that there might not really be any correlation between positive emotion and time perception. Furthermore, the bootstrapped confidence interval also implies that the direction of the relationship in the population is not guaranteed with the current sample and it could in fact work in the opposite direction (Field, 2013).

There was a weak, negative correlation between high cognitive load and time perception, $r = -.154$, $n = 21$, $p > 0.05$, indicating that increased cognitive load is loosely associated with decreased duration judgements. The correlation was not considered statistically significant and the percentage of variance was calculated to be 2%, implying that 2% of the variance in time perception can be explained by the impact of high cognitive load. Similar to the relationship between positive emotion and time perception on the difficult game task, the bootstrapped confidence interval of the relationship between cognitive load and time perception crosses zero, which means that the sampled scores fall outside of 95% of the probable scores in the population and the direction of the relationship is not guaranteed (Field, 2013).

Effect size. To investigate the effect size, Cohen's d was calculated:

$$d = \frac{\overline{X_{Game1Time}} - \overline{X_{FinalTime}}}{\sqrt{\frac{SD_{Game1Time}{}^{2} + SD_{FinalTime}{}^{2}}{2}}}$$

$$d = \frac{2.58 - 2.28}{\sqrt{\frac{(1.33^2) + (0.93^2)}{2}}}$$

$$d = 0.26$$

Testing for differences. The researcher is interested in seeing if there are differences between time perception scores on the easy reading task and the control task. In order to test for these differences, the researcher will use a Wilcoxon Signed Rank Test which is designed to measure differences when participants are tested under two different conditions (Pallant, 2010).

Table 40

Difference for time perception between Game1 and the control task

	FinalTime — Game1Time
Z	-.977[a]
Asymp. Sig. (2-tailed)	.329

Note: [a]Based on positive ranks.

The Wilcoxon Signed Rant Test revealed that there are no statistically significant differences between participant scores on time perception between the difficult reading task and the control task (z = -.98; p < .05).

Effect size. The effect size was calculated for the difference between scores on time perception for the difficult reading task to that of the control task. The calculations are shown below. The effect size $r_{Text1Time}$ = .15 is considered small (Cohen, 1988).

$$r_{Text1Time} = \frac{z}{\sqrt{N}}$$

$$r_{Text1Time} = \frac{.98}{\sqrt{42}}$$

$$r_{Text1Time} = .15$$

The effect size for time perception under the positive emotion low cognitive load condition participants reported for the easy reading task is d = 0.26, which is considered small (Cohen, 1988). This is somewhat unfortunate because it means that the effect that the combination of positive emotion and high cognitive load has on time perception is small and of little practical significance.

In concluding this section, there was an observed effect on time perception that was negatively correlated with emotion and negatively correlated with cognitive load. The effect size was small. The difference in time perception scores between the difficult game task and the control task was not statistically significant according to the Wilcoxon Signed Rank Test and the effect size of the manipulation was small. In other words, a relationship is observed but it is potentially not representative of 95% of the study population and of little practical significance.

Game2: Low cognitive load, positive emotion

This section reports descriptive statistics for the second game task which was considered to be the easier of the two game tasks. The conditions that the researcher attempted to create with this experimental task were low cognitive load and positive emotion. Frequency distributions for the two main independent variables under investigation including emotion (Game2Fun) and cognitive load (Game2Difficulty), as well as the dependent variable time perception (Game2Time) start off the section. Next, an investigation of the relationship between these variables and the effect size of the relationship are reported on.

Descriptive statistics.

Table 41

Descriptive statistics for Game2 (easy game task)

		Game2Fun	Game2Difficulty	Game2Time
N	Valid	21	21	21

Missing	0	0	0
Mean	5.24	3.05	00:02:43
Median	6.00	3.00	00:02:30
Mode	6	2	00:02:00
Std. Deviation	1.868	1.987	00:01:06
Skewness	-.179	1.492	1.321
Std. Error of Skewness	.501	.501	.501
Kurtosis	-.874	2.115	1.657
Std. Error of Kurtosis	.972	.972	.972
Range	6	7	00:04:10
Minimum	2	1	00:01:30
Maximum	8	8	00:05:40

There are 21 participants (n = 21) who responded to the second game task (Game2). Of these participants, the mean self-report score for positive emotion was $\bar{X}_{\text{Game2Fun}}$ = 5.24 out of a maximum 10. Participants were required to respond on a Likert-type scale with 0 being 'no fun at all' and 10 being 'a lot of fun'. The mode was 6. Skewness for fun was negative and participants were clustered around the higher end of the scale. The measures of central tendency along with skewness indicate that participants considered Game2 a fun task and consequently, it stands to reason that the task evoked a positive emotional state in participants. This was the desired emotional state as Game2 was designed to be a positive emotion experimental condition.

The mean difficulty self-report rating was $\bar{X}_{\text{Game2Difficulty}}$ = 3.05. Once again a Likert-type scale was used where 0 was considered 'not difficult at all' and 10 was considered 'very difficult'. Most participants scored Game2 2/10 on difficulty, indicating that it was most probably a low cognitive load task. The positive Skewness for task difficulty indicates that most of the participants were clustered around the low end of the scale, supporting the conclusion that the task induced low cognitive load. The distribution for cognitive load was leptokurtic and indicates that most participant responses were clustered around the mean of

3/10 for difficulty. Once again, this was the desired outcome for the researcher as Game2 was designed to be a low cognitive load experimental condition.

The average duration judgement for Game2 was 02:43 ($\bar{X}_{\text{Game2Time}}$ = 02:43). This was a slight overestimate of the duration of the task that was in fact only 02:00. The longest duration judgement was 05:40 and the shortest was 01:30. The range is quite large at $R_{\text{Game2Time}}$ = 04:10. Skewness for time perception was positive, indicating that participants' responses clustered around the lower end of the scale. Also, the kurtosis of the distribution of scores was leptokurtic, indicating that most participants' time perception was centred close to the mean of 02:43. When describing the distribution of scores, it is evident that participants slightly overestimated the duration of Game2, but the duration judgements were somewhat lower than for the reading tasks. This was contradictory to the literature which predicts that under positive emotion and low cognitive load conditions, duration judgements should decrease (Block & Zakay, 2001; Droit-Volet & Gil, 2009).

To examine the distribution of participant scores for the three variables in question, the researcher now turns to frequency distributions for each of the variables individually. Starting with time perception (Game2Time), then looking at emotion (Game2Fun) and lastly reporting on cognitive load (Game2Difficulty).

Table 42

Frequency distributions of time perception for Game2 (easy game task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	00:01:30	3	14.3	14.3	14.3
	00:02:00	6	28.6	28.6	42.9
	00:02:15	1	4.8	4.8	47.6
	00:02:30	1	4.8	4.8	52.4
	00:02:45	1	4.8	4.8	57.1
	00:03:00	5	23.8	23.8	81.0
	00:03:30	1	4.8	4.8	85.7
	00:04:00	1	4.8	4.8	90.5
	00:05:00	1	4.8	4.8	95.2

00:05:40	1	4.8	4.8	100.0
Total	21	100.0	100.0	

Table 42 shows that 29% (n = 6) participants accurately estimated the time for Game2. Game2 was a low cognitive load, positive emotion condition. The literature predicts that under these conditions, participants are likely to underestimate the duration of an interval (Droit-Volet & Meck, 2007). Of the sample, three participants (14%) underestimated the duration, compared to 12 (57%) who overestimated the interval. This was an interesting and unexpected finding. The researcher will explain this in greater detail when looking at participants self-report responses of how much fun they had (manipulation of positive emotion) while playing the game on the slower and easier setting. If it is demonstrated that participants did not have fun while completing Game2, then the overestimate findings would be supported by the literature that predicts overestimated for neutral emotion or boring tasks.

Table 43

Frequency distributions of positive emotion for Game2 (easy game task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (Not fun)	0	0.0	0.0	0.0
	2	2	9.5	9.5	9.5
	3	2	9.5	9.5	19.0
	4	4	19.0	19.0	38.1
	5	2	9.5	9.5	47.6
	6	6	28.6	28.6	76.2
	7	2	9.5	9.5	85.7
	8	3	14.3	14.3	100.0
	10 (A lot of fun)	0	0.0	0.0	100.0
	Total	21	100.0	100.0	

Table 43 shows the frequency distribution of participants' responses to the self-report question of how much fun they had while completing Game2. On the self-report Likert-type scale, the researcher considers the scores 1-5 as 'not fun' and 6-10 as 'fun'. Of the 21 participants who scored Game2, 48% considered the task to be 'not fun' compared to 52% who considered the task 'fun'. The distribution figures for this dimension are crucial considering that the measures of central tendency, skewness and kurtosis of the distribution indicate that it was a 'fun' task and consequently induced a positive emotional state. The manipulation check indicates that Game2 created a positive emotion condition as expected by the researcher, however, the game scored lower on positive emotion than some of the other experimental tasks including the easy ready task ($\bar{X}_{\text{Text2Fun}} = 6.23$) and the difficult game task ($\bar{X}_{\text{Game1Fun}} = 7.00$). The researcher speculates that the order of the game tasks impacted participant scores for the amount of fun they had playing the easy game task. Many participants responded anecdotally that the slower speed of the easy game task made it more boring and less fun. This could possibly explain why participants considered Game2 a fun task, but did not rate it high on the scale.

Table 44

Frequency distributions of cognitive load for Game2 (easy game task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (Not difficult)	4	19.0	19.0	19.0
	2	6	28.6	28.6	47.6
	3	5	23.8	23.8	71.4
	4	3	14.3	14.3	85.7
	5	1	4.8	4.8	90.5
	8	2	9.5	9.5	100.0
	10 (Very difficult)	0	0.0	0.0	100.0
	Total	21	100.0	100.0	

Table 44 shows the frequency of participant responses on the self-report question related to the difficulty of Game2. The researcher considers scores of 1-5 as 'not difficult' and 6-10 as 'difficult'. As is evidenced in table 44, 91% of participants (n = 19) regarded Game2 as 'not difficult' compared to 9% (n = 2) who rated Game2 as 'difficult'. This could indicate a successful manipulation of cognitive load, but could potentially be an artefact of having Game2 followed by the considerably faster Game1. Participants could have responded that Game2 was 'not difficult' with the implication that it was not as difficult as the previous task (Game1) completed. The question was to rate the difficulty of the task, not to compare the difficulty of the task, however, it would not be an illogical assumption to make that participants inadvertently compared Game2 to Game1 in terms of difficulty. As reported in the previous section discussing scores for Game1, participants were asked if Game2 was easier than Game1. This required them to make a comparison between the tasks. This question was asked after the question to rate the difficulty of Game2. All the participants responded that Game2 was easier than Game1. This does not mean that Game2 was easy, but by comparison it was easier.

Correlation. Table 45 shows the correlation between positive emotion (Game2Fun) and time perception (Game2Time), as well as high cognitive load (Game1Difficulty) and time perception (Game2Time).

Table 45

Relationship between time perception and positive emotion and cognitive load (Game2)

					Game2Time
Spearman's rho	Game2Fun	Correlation Coefficient			-.455*
		Sig. (2-tailed)			.038
		N			21
		Bootstrap[c]	Bias		.021
			Std. Error		.191
			95% Confidence Interval	Lower	-.764
				Upper	-.026
	Game2Difficulty	Correlation Coefficient			-.075
		Sig. (2-tailed)			.746
		N			21
		Bootstrap[c]	Bias		.009
			Std. Error		.250
			95% Confidence Interval	Lower	-.529
				Upper	.487

Note: *Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).

[c]Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples.

The relationship between positive emotion and time perception, as well as the relationship between high cognitive load and time perception was investigated using Spearman's rank order correlation. There was a moderate, negative correlation between positive emotion and time perception, $r = -.455$, $n = 21$, $p < 0.05$, with positive emotion being associated with decreased duration judgements. This was in-line with the literature that predicts when positive emotion increases, duration judgements will decrease (Hancock & Block, 2012). The correlation was considered statistically significant at $p \leq 0.05$ and the percentage of variance was calculated to be 21%. This is to say that 21% of the variance in time perception is attributed to the impact of positive emotion. When looking at the bootstrapped confidence intervals the upper and lower levels do not cross zero which means that the relationship witnessed in the sample fall inside 95% of scores seen in the population. This is to say that the researcher is 95% sure that the relationship observed in the sample occurs in the population (Field, 2013).

There was a weak, negative correlation between high cognitive load and time perception, $r = -.075$, $n = 21$, $p < 0.05$, indicating that increased cognitive load is loosely associated with decreased duration judgements. The correlation was not considered statistically significant and the percentage of variance was calculated to be 0.6%, implying that a mere 0.6% of the variance in time perception can be explained by the impact of high cognitive load. Similar to the relationship between positive emotion and time perception on the easy game task, the bootstrapped confidence interval of the relationship between cognitive load and time perception crosses the zero, which means that the sampled scores fall outside of 95% of the probable scores in the population and the direction of the relationship is not guaranteed (Field, 2013).

Effect size. To investigate the effect size, Cohen's d was calculated:

$$d = \frac{\overline{X_{Game2Time}} - \overline{X_{FinalTime}}}{\sqrt{\frac{SD_{Game2Time}{}^2 + SD_{FinalTime}{}^2}{2}}}$$

$$d = \frac{2.72 - 2.28}{\sqrt{\frac{(1.10^2) + (0.93^2)}{2}}}$$

$$d = 0.53$$

The effect size for time perception under the positive emotion low cognitive load condition participants reported for the easy reading task is d = 0.53, which is considered medium (Cohen, 1988). This implies that there is practical significance for the effect of positive emotion and low cognitive load on time perception. The effect size for the easy reading task, which participants also considered to be fun ($d_{Text2Time}$ = 0.43) was considerably smaller than that of the easy game task.

Testing for differences. The researcher is interested in seeing if there are differences between time perception scores on the easy reading task and the control task. In order to test for these differences, the researcher will use a Wilcoxon Signed Rank Test which is designed to measure differences when participants are tested under two different conditions (Pallant, 2010).

Table 46

Difference for time perception between Game2 and the control task

	FinalTime — Game2Time
Z	-1.458[a]
Asymp. Sig. (2-tailed)	.145

Note: [a]Based on positive ranks.

The Wilcoxon Signed Rant Test revealed that there are no statistically significant differences between participant scores on time perception between the difficult reading task and the control task (z = -1.46; p < .05).

Effect size. The effect size was calculated for the difference between scores on time perception for the difficult reading task to that of the control task. The calculations are shown below. The effect size $r_{Text1Time}$ = .23 is considered small (Cohen, 1988).

$$r_{Text1Time} = \frac{z}{\sqrt{N}}$$

$$r_{Text1Time} = \frac{1.46}{\sqrt{42}}$$

$$r_{Text1Time} = .23$$

In conclusion, the literature predicts that participants would underestimate durations when in a positive emotional state and under low cognitive load (Droit-Volet & Meck, 2007). This was only partially the findings of the present research as participants still tended to overestimate the interval length when compared to the objective length of the interval at two minutes. Participant responses tended to cluster around the lower end of the scale, but they still tended to overestimate the length of the duration. A negative, moderate, statisitcally significant relationship between positive emotion and time perception is noted, but the relationship has a small effect size. Furthermore, the difference between time perception scores under the conditions of positive emotion and low cognitive load are not significantly different to scores under the control conditions.

Control task (final)

This section reports descriptive statistics for the control task. The control task was an empty interval task which did not require participants to perform any primary task. The full sample (N = 22) was used to analyse participant scores for the control task. Frequency distributions for the two main independent variables under investigation including emotion (FinalFun) and cognitive load (FinalDifficulty), as well as the dependent variable time perception (FinalTime) start off the section. Next, an investigation of the relationship between these variables will be reported.

Descriptive statistics.

Table 47

Descriptive statistics for the final task (control task)

		FinalFun	FinalDifficulty	FinalTime
N	Valid	22	22	22
	Missing	0	0	0
Mean		2.23	1.95	00:02:17
Median		1.50	1.50	00:02:15
Mode		1	1	00:02:00
Std. Deviation		1.660	1.327	00:00:55
Skewness		1.526	1.706	.120
Std. Error of Skewness		.491	.491	.491
Kurtosis		2.063	2.955	-.574
Std. Error of Kurtosis		.953	.953	.953
Range		6	5	00:03:00
Minimum		1	1	00:01:00
Maximum		7	6	00:04:00

There are 22 participants who completed the control task (Final). Of these participants, the mean self-report score for positive emotion was $\bar{X}_{\text{FinalFun}} = 2.23$. Participants were required to respond on a Likert-type scale with 0 being 'no fun at all' and 10 being 'a lot of fun'. The mode was $Mo_{\text{FinalFun}} = 1$. Skewness for fun was positive and participants were clustered around the lower end of the scale. Kurtosis was leptokurtic which indicates that participant responses centred on the mean score of 2.23. Despite the range for scores being quite high $R_{\text{FinalFun}} = 6$, the researcher considers the control task to have evoked a neutral emotion condition.

The mean difficulty self-report rating was $\bar{X}_{\text{FinalDifficulty}} = 1.95$. A Likert-type scale was used where 0 was considered 'not difficult at all' and 10 was considered 'very difficult'. The maximum score was 6 out of a possible 10, again, reinforcing the notion that the control task was not experienced by participants as difficult and was a low cognitive load task. Skewness for task difficulty indicates that most of the participants were clustered around the low end of the scale (positive skewness), supporting the conclusion that the task induced low cognitive load.

The average duration judgement for the control task was $\bar{X}_{\text{FinalTime}}$ = 02:17). This was a slight overestimate of the duration of the task that was in fact only 02:00. The longest duration judgement was 04:00 and the shortest was 01:00. The range is fairly small and the lowest for all the conditions at $R_{\text{FinalTime}}$ = 03:00. Skewness for time perception was positive, indicating that participants' responses clustered around the lower end of the scale. The distribution of time perception scores was platykurtic, indicating that too many cases were at the tail ends of the distribution. The mode was $Mo_{\text{FinalTime}}$ = 02:00, which indicates that most participants were able to accurately estimate the interval length.

To examine the distribution of participant scores for the three variables in question, the researcher now turns to frequency distributions for each of the variables individually. Starting with time perception (FinalTime), then looking at emotion (FinalFun) and lastly reporting on cognitive load (FinalDifficulty).

Table 48

Frequency distributions of time perception for the final task (control task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	00:01:00	5	22.7	22.7	22.7
	00:02:00	6	27.3	27.3	50.0
	00:02:30	4	18.2	18.2	68.2
	00:03:00	4	18.2	18.2	86.4
	00:03:15	1	4.5	4.5	90.9
	00:04:00	2	9.1	9.1	100.0
	Total	22	100.0	100.0	

Table 48 shows that 27% (n = 6) participants accurately estimated the time for the control task. The control task was a low cognitive load, neutral emotion condition. It was expected that under these conditions, time perception should be most accurate, but the most participants were able to estimate the difficult reading task (Text1) accurately at 32%.

Of the sample, five participants (23%) underestimated the duration, compared to 11 (50%) who overestimated the interval. The mean average for time perception on the control task was the closest to the target interval of all the tasks. This is to say that participants' time perception on the control task was in fact the most accurate, reaffirming findings from Grondin and Plourde (2007).

Table 49

Frequency distributions of positive emotion for the final task (control task)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1 (Not fun)	11	50.0	50.0	50.0
	2	3	13.6	13.6	63.6
	3	5	22.7	22.7	86.4
	5	2	9.1	9.1	95.5
	7	1	4.5	4.5	100.0
	10 (A lot of fun)	0	0.0	0.0	100.0
	Total	22	100.0	100.0	

Table 49 shows the frequency distribution of participants' responses to the self-report question of how much fun they had while completing the control task. On the self-report Likert-type scale, the researcher considers the scores 1-5 as 'not fun' and 6-10 as 'fun'. Of the 22 participants who completed the control task, 96% considered the task to be 'not fun' compared to 5% who considered the task 'fun'. When looking at the frequency distributions of the final task, the researcher accepts that the task evoked a neutral emotional state in participants. In fact, the control task had the lowest mode of all the tasks with the highest number of participants scoring the task 1/10 for fun and the lowest median ($Mdn_{FinalFun}$ = 1.5).

Table 50

Frequency distributions of cognitive emotion for the final task (control task)

		Frequency	Percent	Valid Percent	Cumulative Percent

Valid	1 (Not difficult)	11	50.0	50.0	50.0
	2	6	27.3	27.3	77.3
	3	2	9.1	9.1	86.4
	4	2	9.1	9.1	95.5
	6	1	4.5	4.5	100.0
	10 (Very difficult)	0	0.0	0.0	100.0
	Total	22	100.0	100.0	

Table 50 is a frequency distribution table of participant responses on the self-report question related to the difficulty of the control task. The researcher considers scores of 1-5 as 'not difficult' and 6-10 as 'difficult'. As is evidenced in table 50, 96% of participants (n = 21) regarded the control task as 'not difficult' compared to 5% (n = 1) who rated the control task as 'difficult'. The researcher considers this as evidence for a successful manipulation of cognitive load and the control task was a low cognitive load task.

Correlation.

Table 51

Relationship between time perception and positive emotion and cognitive load (Final)

					FinalTime
Spearman's rho	FinalFun	Correlation Coefficient			.017
		Sig. (2-tailed)			.941
		N			22
		Bootstrap[c]	Bias		-.004
			Std. Error		.243
			95% Confidence Interval	Lower	-.457
				Upper	.507
	FinalDifficulty	Correlation Coefficient			-.022
		Sig. (2-tailed)			.924
		N			22
		Bootstrap[c]	Bias		.008
			Std. Error		.214
			95% Confidence Interval	Lower	-.410
				Upper	.402

Note: **Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

[c]Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples.

Table 51 shows the correlation between positive emotion (FinalFun) and time perception (FinalTime), as well as high cognitive load (FinalDifficulty) and time perception (FinalTime) for the control task. The relationship between emotion and time perception, as well as the relationship between cognitive load and time perception was investigated using Spearman's rank order correlation. There was a weak, positive correlation between emotion and time perception, $r = .017$, $n = 22$, $p < 0.05$, with a loose relationship between increased positive emotion and increased duration judgements. The correlation was not considered statistically significant at $p < 0.05$ and the percentage of variance was calculated to be 0.03%. This is to say that only 0.03% of the variance in time perception is attributed to the impact of positive emotion. When looking at the bootstrapped confidence intervals the upper and lower levels cross zero which means that the population value could be zero or in other words, the relationship witnessed in the sample could fall outside 95% of scores seen in the population. Furthermore, the bootstrapped confidence interval also implies that the direction of the relationship in the population is not guaranteed with the current sample and it could in fact work in the opposite direction (Field, 2013).

There was a weak, negative correlation between cognitive load and time perception, $r = -.022$, $n = 22$, $p < 0.05$, indicating that increased cognitive load is loosely associated with decreased duration judgements. The correlation was not considered statistically significant and the percentage of variance was calculated to be 0.05%, implying that less than 1% of the variance in time perception can be explained by the impact of cognitive load. The bootstrapped confidence interval crosses zero which means that participant scores from the study sample represent only 5% of the study population. The implication of this is that the observed relationship between cognitive load and positive emotion might not really exist or it might operate in the opposite direction (Field, 2013).

In concluding this section, the control task evoked a neutral emotional, low cognitive load state in participants. The associations between these two independent variables and the dependent variable under these conditions were weak and not of statistical significance. This leads the researcher to accept that the control task is in fact an effective control and useful to test the effect size of the other tasks against the mean and standard deviations of participant score for time perception on the control task.

Chapter 5: Findings

This chapter will discuss in detail the results that were presented in the previous chapter and what the researcher concludes in the form of findings. The discussion aims to make sense of the results by marrying them with what is known from the literature with the specific objective to either accept or reject the research hypothesis. The researcher will start by discussing the research question: What is the influence of positive emotions and cognitive load on time perception in the retrospective paradigm?

Answering the research question

Explaining the role of cognitive load in time perception

In order to answer the research question, Game1 was the experimental condition of most significance to the researcher. The researcher is interested in how time perception is influenced under the conditions of high cognitive load and positive emotion in the retrospective paradigm. The role of cognitive load was somewhat unclear and occasionally, cognitive load was positively correlated with time perception as in the case of the difficult reading task (Text1). This is in-line with what Hancock and Block (2012) would expect in the retrospective paradigm. A negative correlation was reported between cognitive load and time perception in the case of all other experimental tasks including the easy reading task (Text1), the difficult game task (Game1) and the easy game task (Game2), as well as the control task (Final). The negative relationship of these correlations is in-line with what the literature predicted for the prospective paradigm and not the retrospective paradigm (Wittmann, 2009).

The researcher would like to point out that only 38% of participants considered the experimental condition of Game1 as 'difficult'. This is to say that the experimental conditions did not really evoke the state of high cognitive load that the researcher was expecting. Participants considered the second game task as easier than the first, but this does not mean that the task was in fact difficult. This is supported by the frequency distribution and descriptive statistics that relate to cognitive load. In short, the difficult game task was not reported as difficult as the researcher would have liked and it stands to reason that it was possibly not a high enough cognitive load to affect time perception in the expected way. Most participants overestimated the interval, which would be the expected outcome if it was indeed a high cognitive load condition, but the relationship – despite being weak – was negative. The literature predicts a positive relationship between cognitive load and time perception in the retrospective paradigm (Hancock & Block , 2012).

Speculating over the possible reason for the observed negative correlation is that by the time that participants were asked to estimate the duration judgement for the difficult game task, they had already become sensitised to timing. This could inadvertendly result in a prospective duration judgement. In the prospective paradigm, a negative relationship exists between cognitive load and time perception (Tobin & Grondin, 2009). Despite proven methods of studying retrospective time perception for within-subjects design being followed that state that the question of timing should be asked at the end of all the tasks (Grondin, 2008), this could still not be as effective as the researcher would have liked because asking the question repeatedly could potentially alter participants' responses.

Although this is possible, the literature argues that the interval and the primary task had already passed by the time that participants are asked to make the duration judgement. This is to say that logically, the cognitive factors that affect retrospective and prospective timing differently, could not have played a role here. In prospective timing, attention to the secondary task of timing plays a key role in time perception and usually results in underestimates of durations (Brown, 2008). This is not possible in the retrospective paradigm because participants are unaware that they need to pay attention to timing (Block & Zakay, 2001). In the retrospective paradigm, participants rely on their memory of the primary task to estimate the interval length, which tends to result in overestimates. Thus, the researcher concludes that it is not likely that participants inadvertendly respond in the prospective paradigm because they were not able to direct attention to the secondary task of timing while completing the primary task.

Rather, it was noted in the literature review that the role of cognitive load in time perception in the retrospective paradigm is not conclusive (Brown, 2010). A lack of consensus in the scientific community on the cognitive factors that influence time perception in the different paradigms with specific focus on the role of cognitive load could in fact be demonstrated in the present research with the reported results. Similarly, on average, all the task lengths were overestimated. All the mean scores for time perception were higher than the objective length of the interval. The literature predicted this for the high cognitive load tasks like Text1 and Game1, in the retrospective paradigm (Grondin, 2010), but not for the low cognitive load tasks.

Table 52

Summary of time perception means and modes for all research conditions

	Text1Time	Text2Time	Game1Time	Game2Time	FinalTime
Mean	00:02:47	00:02:47	00:02:35	00:02:43	00:02:17
Mode	00:02:00	00:02:00	00:02:00	00:02:00	00:02:00

Also, when looking at table 52, it is evident that there was no systematic difference between mean scores on time perception for the high cognitive load tasks compared to the low cognitive load tasks. The only perceived difference was that the participant scores on the game tasks tended to be closer to the objective time. It could be argued that this was as a result of the role that positive emotion played and how it influenced time perception.

Explaining the role of positive emotion in time perception

Positive emotion tended to be inversely correlated with time perception for the conditions of the difficult reading task, the difficult game task and the easy game task (see table 53). Past research demonstrated that as positive emotion increases, time perception tends to decrease (Droit-Volet & Meck, 2007). In other words, the researcher expected to observe a negative correlation between emotion and time perception as the scale to measure emotion was designed that the maximum score indicated the high positive emotion, and the minimum score indicated low positive emotion (or a neutral emotional state).

The positive correlation between emotion and time perception for the easy reading task made the researcher question participants' responses. The researcher selected an extract from an introductory psychology textbook for this task. The text was selected because of its easy language and because the researcher expected participants to be familiar with the subject matter considering that they were sampled from their university's psychology department. In other words, the text would not be too challenging, but at the same time, not too easy.

Participant scores on positive emotion for the easy reading task were particularly high: $\bar{X}_{Text2Fun}$ = 6.23; $Mo_{Text2Fun}$ = 6. This is to say that participants reported experiencing positive emotions while reading the easy task. The researcher designed the task to invoke a neutral emotional state, not a positive emotional state. The researcher speculates that participants responded that reading the text was fun because they suspected that it was what the researcher wanted them to report. The demand characteristics of the research environment and experimental conditions could have biased participants to respond in this way. Participants were aware that the researcher was conducting a psychology experiment and could have reported enjoying the psychology text because they thought it was what the researcher expected. Gravetter and Forzano (2009) warn against demand characteristics as a potential artefact with experimental designs. If this is the case and the artefact of demand characteristics is present, it would explain why the easy reading task was the only experimental task where positive emotion and time perception was positively correlated instead of the expected and commonly accepted negative correlation (Block & Zakay, 2001; Droit-Volet & Meck, 2007).

Similarly, the control task was an empty interval task. Unbeknownst to the researcher prior to commencing data collection, the study population was learning about mindful meditation as part of their course work. Mindful meditation teaches practitioners to 'clear' their thoughts while concentrating on a natural bodily function like breathing. Anecdotal evidence from participant responses to the manipulation check for positive emotion made the researcher aware that participants said they enjoyed the control task, which was designed to evoke a neutral emotional state. Participants reported qualitatively that they enjoyed practicing mindful meditation during the empty interval task. If participants had been taught that mindful meditation is good and will make you feel better during their classes, then it is likely that this could be a demand characteristic of the control task where participants were only instructed to 'stare at the screen and wait for further instructions.' In other words, participants could have responded that they enjoyed the control task because they thought it was what the researcher expected of them.

This would explain why the positive relationship between positive emotion and time perception exists. However, the researcher questions this as an explanation for the results of the control task because participants reported the lowest levels of positive emotion for the control task when compared to all the experimental tasks. The mean self-report score for fun was very low and the mode even lower at the lowest possible score on the scale: $\bar{X}_{\text{FinalFun}} = 2.23$; $Mo_{\text{FinalFun}} = 1$. This is to say that participants did not report enjoying the control task consistently. Despite the relatively large range for scores on positive emotion for the control task ($R_{\text{FinalFun}} = 6$), the distribution was leptokurtic with a negative skewness and scores tended to be clustered at the lower end of the scale. In short, participants did not report high levels of positive emotion for the control task, so demand characteristics do not seem like a likely explanation for the positive relationship between positive emotion and time perception on the control task.

The most sensible explanation is probably the simplest in the case of the control task. Because participants were not distracted by the impact of a primary task that was designed to manipulate some independent variables, participants were able to estimate interval lengths the most accurately in the control task. This was indeed the case with scores for time perception on the control task the closest to the objective duration of the interval for all the tasks. It is worth noting, however, that for the control task, the reported relationship between positive emotion and time perception, as well as the relationship between cognitive load and time perception, were both in the opposite direction of what the literature predicts (Wittmann, 2009).

Explaining the combined role of emotion and cognitive load in time perception

Only on the game tasks did the influence of emotion and cognitive load on time perception move in the same direction. For both the difficult and easy game tasks, the relationship was negative. The researcher expected the relationship between cognitive load and time perception to be positive, but a weak negative relationship was reported.

Table 53

Summary of correlations between time perception and emotion and cognitive load for all research conditions

	Text1Time	Text2Time	Game1Time	Game2Time	FinalTime
Emotion	-.238	.480*	-.177	-.455*	.017
Cognitive load	.410	-.040	-.154	-.075	-.022

Note: **Correlation is significant at the 0.05 level (2-tailed).

The effect size for the easy game task was medium at $d_{\text{Game2Time}} = 0.53$ (Cohen, 1988), which indicates the practical significance of the impact of positive emotion and cognitive load on time perception. This was the only effect size that fell in the range of a moderate effect, with other effect sizes for both reading tasks falling at the higher end of the range for a small effect. It is worth noting, however, that a measureable effect size was reported for all the experimental tasks.

Table 54

Summary of effect sizes of positive emotion and cognitive load on time perception for all experimental conditions

	Text1Time	Text2Time	Game1Time	Game2Time
Cohen's d	.43	.43	.26	.53

The difficult game task (Game1) had the smallest effect size and was reported at the lower end of the scale for small effect sizes. Cohen (1988) advises that a Cohen's d of between .2 and .49 is considered small. A reported Cohen's d of between .5 and .79 is considered medium, and once it exceeds .8 it is considered large. Cohen (1988) gives other values for other types of correlations, but the mentioned guidelines here are applicable to group comparisons.

Paying particular attention to the difficult game task, it was noted that participants overestimated the amount of time that passed. A negative albeit weak relationship existed between emotion and time perception, which was predicted by the literature (Droit-Volet & Gil, 2009). Participants still overestimated the length of the interval, yet, it is worth reporting that with the exception of the control task, the average time perception was lower on the difficult game task than the other experimental tasks. In other words, participants on average reported the lowest durations judgements for the difficult game task.

The reseacrher concludes that the combined effect of positive emotion and high cognitive load on time perception was small and of little practical significance. However, the condition of positive emotion and high cognitive load produced the lowest average duration judgement for all the experimental conditions ($\bar{X}_{\text{Game1Time}}$ 02:35).

The paradoxical effect that the literature predicts for time perception in the retrospective paradigm under the conditions of positive emotion and high cognitive load, was winessed only to some extent. The correlations are weak and not statistically significant and the effect size is small. However, the researcher cannot fail to not that the overll duration fellt shorter for participants. Of the 11 participants who responded to the question "Which task felt the longest?", none of them picked the difficult game task. Despite the lowest average duration judgement recorded for the control task, four out of 11 participants (36%) reported that the control task felt the longest. The researcher accepts that this is not conclusive evidence, but does accept this as a demonstration of the nuanced nature of studying time perception as reported by Eagleman (2008). Participant responses where intuitively contradictory with many reporting that an interval felt long, but then judged it to be shorter than others.

The researcher also takes this as evidence of the effect that different response methods have on the outcomes of time perception research as mentioned by Grondin (2008). Participants can give contradictory responses depending on the question asked. When participants where asked to give a value to the duration ('In minutes and seconds, how much time passed while you were completing the task?'), they tended to over-estimate the length of the duration when compared to the objective length of the interval. When particpants where asked to rank the durations ('Which task felt the longest?'), they often did not rank the task that they attirbuted the highest value to, as being the longest.

The slow pace of the easy game task also potentially influenced participants to report that the easy game task (Game2) felt the longest . Three out of the 11 participants who were asked which task felt the longest responded that the easy game task felt the longest (27%). The literature predicts that the rhythm of slow music impacts time perception in that it results in over-estimates (Droit-Volet, Bigand, Ramos, & Bueno, 2010), but that this effect can be countered as a consequence of participants' enjoyment of the music. The researcher could not find evidence for a slow down effect in the area of video games, but suspects that a similar confounding effect might be at work in the present research. In other words, because the pace of the easy game task was lower, this could have led to participants reporting that the task felt long. The effect size for the easy game task is medium and by far the largest of all the reported effect sizes. A significant, moderate, negative correlation exists between positive emotion and time perception for the easy game task. The average time perception for the easy game task is $\bar{X}_{\text{Game2Time}}$ = 02:43 which is a considerable over-estimate. There are two possible explanations: either the slow pace of the game made the task less enjoyable, which resulted in increased duration judgements, or the slow pace of the game acted as a confounding variable that systematically influenced the relationship between the dependent and independent variables.

Despite not being able to rule out the second possibility, the literature and the results from the present research give more support to the first explanation (Sucala, Scheckner, & David, 2011). The lower pace of the game made it less fun and resulted in overestimates. Taking into account that participants reported lower average levels of fun for the easy game task when compared to the difficult game task, it seems more probable that the slower pace of the easy game task explains this difference as the two game tasks were exactly the same game with the only difference being the pace. Similarly, if positive emotion remained the same, the literature predicts that the high cognitive load task would result in an overestimation (Block, Hancock, & Zakay, 2010). In other words, if participants enjoyed the game tasks equally, they would be more likely to overestimate the high cognitive load task than the low cognitive load task. The impact of the slow pace of the easy game task most likely resulted in participants enjoying the task so much less, that their time perception increased significantly.

This impact was possibly amplified by the sequence of the tasks. Participants first played the game at the higher pace to make it more difficult, however, after playing the game at the high pace for two minutes, participants probably became used to the excitement of the fast pace and the slow pace felt boring in comparison. Boredom can influence time perception and result in overestimations (Watt, 1991), and can be the consequence of less than optimal cognitive load (Zakay, 2014). When combinging the comparatively slow pace, the lower levels of enjoyment and the decreased cognitive load, it is understandable that participants experienced Game2 as a longer task and overestimated time perception.

In summary, time perception scores on the difficult game task was in-line with what the literature predicts. The high cognitive load, neutral emotion task resulted in an overestimate of time and there was a moderate, positive correlation between cognitive load and time perception. Participants reported a positive emotional state on the easy reading task, but psotive emotion and time perception was negatively corelated. This led the researcher to believe that a possible demand characteristic could be at work and that participants reported that the psychology text was more fun to read than what they really experienced. The difficult game task was of most interest to the researcher. The results were dissappointing as the effect size was calculated to be the lowest. None of the participants who were asked which task felt the longest selected Game1 and the mean time perception for Game1 was the lowest, leading the researcher to conclude that despite high duration estimates, participants did not experience the task as longer than any of their other tasks. The easy game task possible fell foul to the confounding effect of boredom, but a moderate, statistically significant negative correlation is reported between positive emotion and time perception on Game2. The effect size, however, is small. The control task was perceived most accurately with mean time perception closest to the objective duration of the task.

Accepting the research hypothesis

When taking all the findings into account, the researcher accepts the statistical hypothesis that states there are no significant diffirences between the mean time perception scores on the various experimental and control tasks, as illustrated by the following:

H_0: $\mu_{Text1Time} = \mu_{Text2Time} = \mu_{Game1Time} = \mu_{Game2Time} = \mu_{FinalTime}$

The researcher then fails to accept the research hypothesis that participants' perception of time in retrospect is influenced by their emotional state and cognitive load.

H_1: $\mu_{Text1Time} \neq \mu_{Text2Time} \neq \mu_{Game1Time} \neq \mu_{Game2Time} \neq \mu_{FinalTime}$

Chapter 6: Conclusion and limitations

The limitations of the present study are vast as the factors that influence time perception are numerous and our theoretical understanding of these factors is incomplete (Wittmann, 2009). The researcher will discuss a few key limitations that are considered to have had the greatest impact on the present research in this section. The final chapter of this report also attempts to advise on how future research can improve on the limitations experienced in the present research as well as identifying ptential new avenues of research.

Limitations of the present research

Use of eye tracker

The use of the eye tracker was problematic in the present study for two main reasons. Firstly, the eye tracker limited the number of participants that could be tested during each experimental session to one. This made collecting data time consuming and inefficient as no other aspect of the study required that the researcher sit with one participant at a time. The eye tracker was expected to provide invaluable physiological data on cognitive load by measuring pupil dilation. This is the principle justification for the use of the device.

Secondly, the eye tracker is a delicate piece of equipment that is difficult to calibrate and when the device broke mid-way through data collection, it could not be repaired or replaced in a timely manner. This is a problematic situation because several participants participated in the experiment with the eye tracker. Furthermore, the information sheet told participants that the purpose of the study was to investigate the influence of positive emotion and cognitive load on pupil dilation. In addition, the researcher had distributed the information sheet to the study population as part of the recruitment process. If the researcher was to remove the eye tracker from the experimental design it would mean that new study population had to be found because information in the information sheet had to be changed and all the participants who were already sampled would have to be removed from the data.

After consulting with external sources, the researcher decided to remove the eye tracking data component from the data set and continue with the experiment by putting the broken eye tracker on participants and pretending to calibrate the device. This meant that all participants were tested under the same experimental conditions, despite not having physiological data from the eye tracker for everyone.

Small sample size

Related to the use of the eye tracker, the small sample size made statistical analysis and drawing inferences from the data difficult. The study population was limited, which also meant that the researcher would not be able to gather a large sample. The literature suggested that a small sample of 16 participants would be sufficient for the type of experimental design (Tobin & Grondin, 2009). The small study population was the motivation for doing a within-subjects design, which had its limitations in the area of studying retrospective time perception. The present research followed best practices when conducting a repeated-measures retrospective time perception study (Grondin & Plourde, 2007) and this helped to get greater depth of information out of the small sample.

The small sample size also means that the researcher could only use non-parametric statistics which tend to be less powerful than the parametric alternatives. This makes it difficult to draw conclusive inferences from the data. As a consequence of the small sample size, the researcher is more prone to a Type II error, when the sample does not show evidence of a significant effect when a real effect occurs in the population. The researcher found almost no statistically significant correlations and the effect sizes where all small with only one medium effect size.

Self-report questionnaires

Self-report measures are notoriously open to subjective bias and possible distortion from participants (Gravetter & Forzano, 2009). It is noted that participants might deliberately lie or distort the truth to present them in a better light. Participants could also unintentionally distort the truth by responding in a way that they think is socially acceptable or what they believe the researcher is expecting.

This was particularly problematic when participants reported on both their emotional states and the cognitive load they experienced while completing the primary tasks. The researcher suspects that participants experienced demand characteristics during the second reading task considering that it was a text on psychology and the participants were aware that the researcher was also studying psychology. The researcher is unable to verify this because only a self-report measure was used.

Similarly, it is possible that participants understated the amount of cognitive load they experienced when asked about the task difficulty. It would not be unnatural for participants to want to represent themselves in a more favourable light by downplaying the difficulty of a certain task. Some participants noted that the difficult reading task was not really difficult and that they rather enjoyed reading it. This is unlikely considering that the extract was from the natural sciences and written in 40 year old academic English. Once again, the researcher's suspicions cannot be verified because there are not data to test participant responses against.

That being said, the researcher justifies the use of the self-report questionnaire because it is one the most direct ways to measure constructs like emotion and cognitive load (Gravetter & Forzano, 2009). Self-report measures are also associated with high face validity. Ideally, the researcher would have liked to augment this data with physiological data from the eye tracker, but even if this was the case, the researcher still did not have a physiological measure of positive emotion.

Conclusion

The present research investigated the paradoxical effect of positive emotion and high cognitive load on time perception in the retrospective paradigm. In order to do this, the researcher devised an experiment with four experimental conditions manipulating two levels of the two independent variables under investigation and one control condition. The conditions included a difficult and an easy reading task, a difficult and an easy game task and the empty interval control task. The difficult game task is of particular interest as this is the task that is the positive emotion, high cognitive load experimental condition.

Time perception scores on the difficult reading task are in-line with what the literature predicts. The high cognitive load, neutral emotion task resulted in an overestimate of time and there was a moderate, positive correlation between cognitive load and time perception. However, the effect size of this relationship is small and time perception scores on the difficult reading task are not statisitcally different from time perception scores on the control task.

Participants reported a positive emotional state on the easy reading task, but positive emotion and time perception was positively corelated. The direction of this relationship contradicts what the literature predicts and the results from the bootstrapped sample indicated that the direction of the relationship is what would be observed in 95% of the study population. This led the researcher to believe that a possible demand characteristic could be at work and that participants reported that the psychology text was more fun to read than what they really experienced. If this was in fact the case, then the direction of the relationship would change and become negative.

The difficult game task was of most interest to the researcher. The results were dissappointing as the effect size was calculated to be the lowest of all the experimental conditions. However, none of the participants who were asked which task felt the longest selected Game1 and the mean time perception for Game1 was the lowest with the exception of the control task. This leads the researcher to conclude that despite high duration estimates, participants did not really experience the task as longer than any of the other tasks. Time perception scores on the difficult game task was the closest to the control task, which could also imply that under the condition of high cognitive load and positive emotion, participants become more accurate when estimation intervals.

The type of question posed when measuring time perception plays a role in participant responses (Boltz, 2005). The easy game task possibly fell foul to the confounding effect of boredom, but a moderate, statistically significant negative correlation is reported between positive emotion and time perception on Game2. The effect size, unfortunately, is small according to Cohen (1988). The control task was perceived most accurately with mean time perception closest to the objective time of the task.

In conclusion, the researcher fails to accept the research hypothesis that there are statistically significant differrences in mean time perception scores between the various conditions. A relationship of statisitcal significance was reported for some of the experiemental conditions between the independent and dependent variables, however, further statisitcal analysis demonstrated that when such a relationship exists, it had only a 5% chance to be observed in the study population, the effect size was small to moderate and the difference between the experimental and control conditions was not significant. All in all, the researcher accepts the statistical hypothesis and concludes that the influence of positive emotion and high cognitive load on time perception is not of statisitcal significance.

Of practical significance is that when participants have to estimate intervals while not doing anything else (control task) then their time perception is the most accurate. It is not sensible to tell people to do nothing in order to have the most accurate time perception, but rather when participants are challenged with a fun task (difficult game task), then their time perception is closest to accurate when compared to other activities. This is to say that practically, time flies when you are having fun, but it also flies when you are busy.

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Appendix A

Questionnaire

Cover page.

Experiment: (1) / (2)

Participant number: ________

Date of session: ______________________

Time of session: ______________________

Gender: (M) / (F)

Age:________

Cover question 1: Did you read the information sheet? (Y) / (N)

Cover question 2: Did you understand the information sheet? (Y) / (N)

Cover question 3: Did you sign an informed consent form? (Y) / (N)

Cover question 4: Do you have any questions before we begin? (Y) / (N)

Questions:

____

____

____

Comments/observations:

____

____

____

Reading tasks.

Questionnaire to be administered after reading the text at the highest difficulty level (neutral emotion, high cognitive load)

I will now ask you a couple of questions about the text you just read. Please answer the following questions by verbal response.

Question 1:

On a scale of 1 to 10, with one being no fun at all and 10 being a lot of fun, rate how much fun you had reading the text.

Answer 1:

____

Question 2:

On a scale of 1 to 10, with one being not difficult at all and 10 being very difficult, rate how difficult it was reading the text.

Answer 2:

____

Question 3:

In minutes and seconds, how much time passed while you were reading the text?

Answer 3:

____ minutes and ____ seconds

Question 4:

Was the style of the text academic?

Answer 4:

____

Question 5:

Was the text about psychology?

Answer 5:

____

Questionnaire to be administered after reading the text at the lowest difficulty level (neutral emotion, low cognitive load)

I will now ask you a couple of questions about the text you just read. Please answer the following questions by verbal response.

Question 1:

On a scale of 1 to 10, with one being no fun at all and 10 being a lot of fun, rate how much fun you had reading the text.

Answer 1:

____

Question 2:

On a scale of 1 to 10, with one being not difficult at all and 10 being very difficult, rate how difficult it was reading the text.

Answer 2:

____

Question 3:

Was the text about psychology?

Answer 3:

____

Question 4:

Was the style of the text academic?

Answer 4:

____

Question 5:

Was it more difficult reading this text than the previous text?

Answer 5:

____

Game tasks.

Questionnaire to be administered after playing Digger at the highest difficulty level (positive emotion, high cognitive load)

I will now ask you a couple of question about the game you just played. Please answer the following questions by verbal response.

Question 1:

On a scale of 1 to 10, with one being no fun at all and 10 being a lot of fun, rate how much fun you had playing Digger.

Answer 1:

____

Question 2:

On a scale of 1 to 10, with one being not difficult at all and 10 being very difficult, rate how difficult it was playing Digger.

Answer 2:

____

Questionnaire to be administered after playing Digger at the lowest difficulty level (positive emotion, low cognitive load)

I will now ask you a couple of question about the game you just played. Please answer the following questions by verbal response.

Question 1:

On a scale of 1 to 10, with one being no fun at all and 10 being a lot of fun, rate how much fun you had playing Digger.

Answer 1:

____

Question 2:

On a scale of 1 to 10, with one being not difficult at all and 10 being very difficult, rate how difficult it was playing Digger.

Answer 2:

____

Question 3:

Was it easier playing Digger this time than the last time?

Answer 3:

____

Question 4:

Did you notice the game was slower this time when compared to last time?

Answer 4:

____

Control condition.

Questionnaire to be administered after the final waiting task.

I will now ask you a couple of question about the task you just completed. Please answer the following questions by verbal response.

Question 1:

Where you waiting just now?

Answer 1:

____

Question 2:

On a scale of 1 to 10, with one being no fun at all and 10 being a lot of fun, rate how much fun you had just now.

Answer 2:

____

Question 3:

On a scale of 1 to 10, with one being not difficult at all and 10 being very difficult, rate how difficult the task was just now.

Answer 3:

____

Time perception.

Questionnaire to be administered after all research conditions have been completed

Give the first response that comes to mind.

Question 1:

Which of the tasks felt the longest?

Answer 1:

____

Answer as accurately as possible.

Question 2:

In minutes and seconds, how much time passed while you were reading the first text?

Answer 2:

____ minutes and ____ seconds

Question 3:

In minutes and seconds, how much time passed while you were reading the second text?

Answer 3:

____ minutes and ____ seconds

Question 4:

In minutes and seconds, how much time passed while you were playing Digger the first time?

Answer 4:

____ minutes and ____ seconds

Question 5:

In minutes and seconds, how much time passed while you were playing Digger the second time?

Answer 5:

____ minutes and ____ seconds

Appendix B

Script: Instructions

Reading task. Please read the provided text that will appear on the laptop screen. Use the arrow key to scroll down as you read. When the alarm goes off, please stop immediately and rest your eyes by closing them.

Game task. For the following tasks you will be required to play a computer game called Digger. Use the arrow keys to navigate the Digger and collect as many emeralds as possible. Avoid the monsters, because they can kill your digger. You have three lives. After you lost three lives and the game ends, it will return to the start screen, click on "start" to start again. You should keep playing until the alarm goes off. When the alarm goes off, please stop immediately and rest your eyes by closing them. The game might continue in the background, just ignore this and wait for the researcher's further instructions.

Final task. Please look at the computer screen and wait for further instructions. When the alarm goes off, please rest your eyes by closing them.

Appendix C

Reading text 1: Difficult reading text

The Allopatric model and phylogeny in Palaeozoic invertebrates

Time is the one element of paleontological data that mitigates, to a degree, the disadvantages inherent in the fossilisation process. Addition of this fourth dimension to evolutionary biology has greatly sharpened our perspective of both rates and modes of evolutionary processes. Palaeontologists have understandably emphasised the importance of time in the elaboration of evolutionary models, and have made particularly important contributions in the general area of the origin of higher taxa. The concept of gradualism, an important aspect of geological thinking (see Simpson, 1970), has permeated paleontological thought to the extent that all phylogenetic change is generally conceived to occur by small increments over vast periods of time. This dominantly phyletic model of transformation, stressing the importance of time and the aggregation of large numbers of small steps of morphological change, has underlain most paleontological discussions of origin of new taxa, including species. In fact, this phyletic model applies not only to strict cases of phyletic transformation (i.e. linear trends in which arbitrary segments are viewed as "new" taxa), but also to most discussions of diverging stocks from a parent group.

At the species level, the only such level in the taxonomic hierarchy where a taxon can actually be said to exist in nature, such a gradualistic view of the origin of new taxa is, in one sense at least, clearly at odds with currently accepted views of speciation derived from studies of the recent biota. On the one hand, while it cannot be denied that a gradual, strictly phyletic, progressive change in species-stock has eventually led to populations of individuals sufficiently distinct phynotypically (and probably genotypically) to warrant recognition of a "new" species, a model which would allow single or multiple splittings of the lineage into new species during the same time span is the more satisfactory explanation of the diversity of life since the Cambrian. On probabilistic grounds alone, we must conclude that the overwhelming majority of metazoan species that have appeared on the earth's surface arose through some process of splitting.

On the other hand, paleontological analyses of lineage splitting have generally dealt only with morphological divergence and do not fully correspond to neontological discussion s of speciation. A biological species concept has been incorporated into palaeontology only relatively recently (see general discussions by Newell, 1956; Imbrie, 1957, and two excellent recent studies by Waller, 1969; Gould, 1969). Since, in favourable circumstances, palaeontologists have been successful in recognising true "biospecies" on criteria which are valid and complete as those used to differentiate the majority of recent species, a reappraisal of paleontological models of speciation is called for.

Of the various models of speciation proposed and discussed over the past forty years, the allopatric model has gained nearly total acceptance among current evolutionary biologists. I would suggest that the allopatric model (geographic speciation) be substituted in the minds of palaeontologists for phyletic transformism as the dominant mechanism of the origin of new species in the fossil record, and that the allopatric model, rather than gradual morphological divergence, is the more correct view of the processes underlying cases of splitting already documented by numerous workers.

Recognition of ancestral-descendant relationships in the fossil record are often based essentially on biostratigraphic data. Actually, such relationships in fact constitute untestable hypotheses. The ancestral-descendent relationship presented below for the various taxa of the *Phacops rana* complex should be viewed as such hypotheses. The theory of (cladistics) relationships, upon which these hypotheses of ancestral-descendent relationships are based, is set forth in detail in Eldredge (1969).

Environments of paleozoic epeiric and marginal cratonal seas

Sediments deposited in the extensive Paleozoic seas that covered much of the continental interior of North America have yielded vast quantities of invertebrate fossils. These extensive epeiric seas have been conceived of as predominantly warm, shallow bodies of water in which general environmental conditions were rather homogeneous within broad bands parallel to shorelines (Shaw, 1964); diurnal fluctuations in physical environment parameters were presumably negligible when compared to environments of the marginal basins.

Reading text 2: Easy reading text

What is psychology?

Your initial answer to this question is likely to bear little resemblance to the picture of psychology that will emerge as you read through this text. I know that when I walked into my introductory psychology class more than 30 years ago, I had no idea what psychology was. I was a pre-law/political science major fulfilling a general educational requirement with what I thought would be my one and only psychology course. I encountered two things I didn't expect. The first was to learn that psychology is about a great many things besides abnormal behaviour and ways to win friends and influence people. I was surprised to discover that psychology is also about how people are able to perceive colour, how hunger is regulated in the brain, whether chimpanzees can use language to communicate, and a multitude of other topics I'd never thought to wonder about. The second thing I didn't expect was that I would be so completely seduced by the subject. Before long I changed majors and embarked on a career in psychology – a decision I never regretted.

Why has psychology continued to fascinate me? One reason is that psychology is practical. It offers a vast store of information about issues that concern everyone. These issues range from broad social questions, such as how to reduce the incidence of mental illness, to highly personal questions, such as how to improve your self-control. In a sense, psychology is about you and me. It's about life in our modern world. The practical side of psychology will be apparent throughout this text, especially in the end of chapter Personal Applications. These applications focus on everyday problems, such as coping more effectively with stress, improving memory, enhancing performance in school, and dealing with sleep difficulties.

Another element of psychology's appeal for me is that it represents a powerful way of thinking. We are all exposed to claims about psychological issues. For instance, we hear assertions that men and women have different abilities or that violence on television has a harmful effect on children. As a science, psychology demands that researchers ask precise questions about such issues and that they test their ideas through systematic observation. Psychology's commitment to testing ideas encourages a healthy brand of critical thinking. In the long run, this means that psychology provides a way of building knowledge that is relatively accurate and dependable.

Of course, psychological research cannot discover an answer for every interesting question about the mind and behaviour. you won't find the meaning of life or the secret of happiness in this text. But you will find an approach to investigating questions that has proven to be fruitful. The more you learn about psychology as a way of thinking, the better able you will be to evaluate the psychological assertions you encounter in everyday life.

There is still another reason for my fascination with psychology. As you proceed through this text, you will find that psychologists study an enormous diversity of subjects, from acrophobia (fear of heights) to zoophobia (fear of animals), from problem solving in apes to the symbolic language of dreams. Psychologists look at all the seasons of human life, from development in the womb to the emotional stages that people go through in the process of dying. Psychologists study observable behaviours such as eating, fighting and mating. But they also dig beneath the surface to investigate how hormones affect emotions and how the brain registers pain. They probe the behaviour of any number of species, from humans to house cats, from monkeys to moths. This rich diversity is, for me, perhaps psychology's most appealing aspect.

Mental illness, rats running in mazes, the physiology of hunger, the mysteries of love, creativity, and prejudice – what ties all these subjects together in a single discipline? How did psychology come to be so diverse? Why is it so different from what most people expect? If psychology is a social science, why do psychologists study subjects such as brain chemistry and the physiological basis of vision? To answer these questions, we begin our introduction to psychology by retracting its development. By seeing how psychology grew and changed, you will discover why it has the shape it does today.

Appendix D

Information Sheet

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Humanities
Department of Psychology

August 2013

Dear Participant,

RESEARCH STUDY: Effects of positive emotion and cognitive load on pupil dilation

There are two parts to this informed consent form:

- An information sheet (to provide information about the study)
- A consent form (to 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 is affiliated with the University of Pretoria and is conducting research aimed at understanding the interaction between positive emotion and cognitive load (mental activity) on pupil dilation.

Participation

The research will involve your participation in two ways: You will be required to play a computer game on the computer and to read an extract from a book displayed on the computer screen. You will be required to wear an eye tracking device for the duration of the experiment, which will measure your pupil dilation for each task. The device is attached to a headset with an elastic band that goes around your head. On the elastic band, is a battery pack, a small infra-red camera and an infra-red light. The camera will be aimed at your eye and it will measure your pupil dilation. You should not feel any discomfort from the eye tracker.

The data gathered by means of the eye tracker will remain confidential and will only be accessed by the researcher. Your participation will be kept anonymous, which means that neither your name nor any other identifying details will be shared with anyone. If you wish to remain informed on the results of the study, you may contact the researcher for further information (contact details provided below).

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

Potential risks or discomfort

The eye tracking device is non-invasive and the researcher does not foresee any discomfort during the research process; however you are encouraged to report any discomfort to the researcher so that the situation may be rectified.

Benefits of participation

The study will not provide any direct benefit to you, but your participation will contribute to a better understanding of the interaction between positive emotion and cognitive load on pupil dilation.

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

Ms Minnette D. Nieuwoudt

Tel: 072 356 4289
Email: minnette.nieuwoudt@gmail.com

Research supervisor:
Prof. D. Maree
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Informed consent form

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Faculty of Humanities
Department of Psychology

August 2013

RESEARCH STUDY: Effects of positive emotion and cognitive load on pupil dilation

Part 2: Consent to participate

I hereby confirm that I have been informed about the nature, procedures, and risks of this study. I also give permission that the eye tracking device may be used, as explained in the information sheet. I am aware that the information will only be used for research purposes, and that my confidentiality will be protected. I 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!