COGNITIVE BIAS MODIFICATION: THE EFFECT OF MENTAL IMAGERY ON REACTION RATE TO EMOTIONALLY VALENCED STIMULI

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ABSTRACT

A normative experimental study was undertaken to establish whether engaging in positive, negative, and neutral mental imagery affected the reaction rate of participants to positive, negative, and neutral word stimuli. The sample consisted of computer literate, English speaking participants with no history of clinical disorders. A total of 80 participants took part in the study, with 40 participants from either gender. The results of a factorial ANOVA indicated that the type of mental imagery engaged in had a significant effect on the rate at which participants responded to stimuli ($p=.00023$, $F=8.4057$), whilst the emotional valence of the stimuli did not have a significant effect ($p=.30503$, $F=1.1877$). However, the interaction between the type of mental imagery and the emotional valence of the stimuli was highly significant ($p=.00794$, $F=3.4576$), thereby indicating that engaging in positive or negative mental imagery did bias participants towards a faster reaction rate to positive or negative stimuli respectively.

Key Terms

Cognitive Bias Modification; Emotionally valenced stimuli; Attention bias; Mental imagery; Depression; Reaction rates; Word valence; ANEW list; Potential therapeutic method

Declaration

Student No.: 4904 748 5

I declare that "Cognitive Bias Modification: The effects of mental imagery on the reaction rate to emotionally valenced stimuli" is my own work and that all the sources used or quoted have been indicated and acknowledged by means of complete references.

Signed:

______________________________ 20/07/2014

Erika C. S. Kunstler Date

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CHAPTER 1
INTRODUCTION

1.1 Introduction

An old adage claims that every cloud has a silver lining. Yet pessimists steadfastly refuse to see the positive side of a negative situation, whilst optimists adopt a more positive focus. Could this difference result from pessimists imaging the situation to be worse than it really is whilst optimists envision the situation more favourably? If a person's expectation of the world influences how that person interprets the world, could those expectations be manipulated in order to alter how the world is seen? Previous research has indicated that people can be instructed to think about situations differently, which does affect how such people view situations (Holmes, Lang, & Shah, 2009). However, as detailed in the following chapter, the efficacy of such verbal thought alteration leaves much to be desired. This raises the question as to how else such expectations can be altered, with one possibility being to consider whether mental imagery would not be more effective in changing how a person views a situation. If a person engages in positive imagery, does that influence the person to process positive information faster than if the imagery were neutral or negative? Put another way, can positive mental imagery bias the person to preferentially process information in a positive light? Conversely, does engaging in negative mental imagery result in that person being more biased towards negative information? As the way in which a person interprets information plays a role in the aetiology and maintenance of emotional disorders such as depression (Holmes et al., 2009), a better understanding of how mental imagery interacts with the types of stimuli which a person processes could lead to important advances in the identification and treatment of such disorders.

1.2 Problem statement and research aims

As can be seen from the introduction, much is still unclear about the relationship between a person's mental imagery and how that influences the person's view of the world. The main aim of this study is therefore to further the understanding of the link between mental imagery and the valence of stimuli, as well as to explore whether this may influence the processing rate of stimuli. This is done by examining how various mental imagery scenarios affect the rate at which emotionally valenced stimuli are reacted to. To this end, it is hypothesised that engaging in positive mental imagery will result in a person being quicker at responding to positive stimuli. Vice versa, negative mental imagery will bias a person to react to negative stimuli faster than to either positive or emotionally neutral stimuli.

One of the main premises of this study is that a person's expectation of a situation makes that person more likely to interpret the situation accordingly. For example, a neutral event such as going to a place for the first time may be influenced by one's expectations. Thus, if a person hears that the service at a new restaurant is slow, that person may try out the restaurant with the expectation of receiving slow service, and may rate the service as being slower than they would have otherwise rated the service. The idea that expectations influence a person's interpretation of situations gives rise to questions such as whether it is possible that a person with depression interprets a neutral situation negatively because he or she expects the situation to be negative. Studies have indeed shown that people suffering from emotional disorders, such as depression and anxiety disorders, have thinking styles heavily influenced by cognitive biases, such as negative interpretation biases (Holmes et al., 2009). An interpretation bias occurs when there is an increase in the likelihood that an ambiguous stimulus will be construed as either being positive or negative, depending on whether the interpretation bias is itself positive or negative (Lang, Blackwell, Harmer, Davidson, & Holmes, 2012). In such a case, a person with depression would automatically process negative cues in his or her environment faster than positive cues, and may even allocate increased cognitive resources to the processing of negative cues, at the expense of positive ones. This shows that biases can result in faster processing of stimuli. But what exactly is meant by "faster processing"?

Although the central assumptions underlying this study will be elucidated further in Chapter 2, it must be noted that the core foundation of this study is that a cognitive bias will lead to faster processing of certain stimuli, with the hypothesis under investigation being that mental imagery can be used to establish a cognitive bias. As is noted by Calvo, Avero, Castillo, and Miguel-Tobal (2003), how stimuli are processed cognitively is greatly affected by the emotions which are evoked by the stimuli. Emotional stimuli which have a similar valence to one's own current emotional state have been found to be processed preferentially over other dissimilar valenced stimuli. Studies indicate, for example, that when a person is anxious about something, he or she preferentially processes threat related stimuli, and is therefore faster at recognising threatening stimuli than any other stimuli, as can be seen in studies which examine event-related potentials (Calvo et al., 2003). Furthermore, Lang and Bradley (2009) demonstrated that stimuli which are emotionally salient or valenced are preferentially attended to when distracting stimuli are non-valenced. In other words, relevant stimuli are attended to preferentially, and therefore processed faster, especially when competing stimuli are deemed not to be relevant. However, the mechanics of how emotionally valenced stimuli are processed will be discussed more fully later in the chapter, in the section entitled "1.5 Stimulus Valence". Nevertheless, the hypothesis which is to be tested through the current study is that this faster processing can be induced through the use of mental imagery. Bearing this in mind, the key concepts underlying the study will now be examined.

1.3 Cognitive Bias Modification

Before going on to define cognitive bias modification, one must first understand what is meant by cognitive biases. Thus, this section will start out by exploring what is meant by the term "cognitive bias" before going on to look at Cognitive Bias Modification theory and how such cognitive biases can be altered.

1.3.1 Cognitive biases

A cognitive bias can be broadly defined as a belief being formed even though such a belief is not entirely justifiable logically (Haselton, Nettle, & Andrews, 2005). From an evolutionary standpoint, cognitive biases fall into three basic categories: Artifact, Error management, and Heuristic biases. Haselton et al. (2005) defines these three types of cognitive biases as follows: *Artifact biases* refer to those biases which are an outcome of research strategies and typically result from flawed research designs. *Error management biases* on the other hand usually involve factoring the cost-effectiveness of various options before selecting the seemingly least-costly error when searching for solutions. Finally, *heuristic biases* arise as a method of increasing information processing efficacy, for example through the use of stereotypes. Although cognitive biases are normally seen as adaptive, they may become maladaptive, which may contribute to the development of emotional disorders (Lang et al., 2012). For example, Levens and Gotlib (2010) propose that a cognitive bias which maintains negative information in working memory may explain why people with depression have a negative mood more often than people who do not have depression.

This study focuses on heuristic cognitive biases, as its aim is to uncover the degree to which mental imagery influences the processing speeds of various types of stimuli. The heuristic explanation of cognitive biases theorises that such biases are a result of attempts at overcoming limitations in information processing resources. This premise is based on the information processing paradigm, a theory which inherently assumes cognitive resources to be limited (Hertwig & Todd, 2003). According to this system, the two key limitations on cognitive processes are storage capacity and the capacity of information processing, and it is further hypothesised that these limitations present a burden which constricts cognitive potential. To compensate for these limitations, adults utilise cognitive shortcuts which allow them to deal with environmental demands, especially when such tasks are unfamiliar (Hertwig & Todd, 2003). Thus, in the context of this information processing theory, cognitive biases may be seen as mental shortcuts which allow a person to process information faster (Haselton et al., 2005). There is a myriad of different types of cognitive biases, including social biases, memory biases, and error biases, each of which can have a great impact on how a person perceives, attends to, and processes incoming sensory information. Most pertinent to the current study is the attentional bias in which a person is preferentially attentive to certain cues in his or her environment, at the expense of other salient cues (Bar-Haim, 2010). As noted by Bar-Haim (2010), attention biases mainly occur at a subconscious level making it difficult for conventional therapy to directly manipulate such biases. This in turn results in difficulties treating disorders which are founded on biased cognitive processes. Consequently, it has been found that maladaptive attentional biases, especially those formed in response to emotionally charged information, are an integral part of current models of emotional disorders, and such cognitive biases affect how the person interprets and attends to information, as well as influencing what information the person remembers (Browning, Holmes, & Harmer, 2010).

But this still leaves the question concerning how cognitive biases are observed in experiments. Studies on cognitive biases typically rely on baselines of the behaviour under study. Thus, cognitive biases may be observed as normative deviations (Caverni, Fabre, & Gonzalez, 1990). In other words, the strength of a cognitive bias can be determined by the degree to which the biased behaviour differs from the typical baseline of that behaviour. One must also consider when and how these biases occur. There has been some debate as to whether attentional biases are automatic or strategic. In other words, automatic biases occur without the participant being consciously aware of recognising the stimulus, whilst strategic biases occur when the participant can consciously recognise the stimulus. However, a recent review of past research suggests that both automatic and strategic attentional biases may take place, with one preceding the other based on the demands of the task being undertaken (Cisler, Bacon, & Williams, 2009). It has been proposed that this attentional bias occurs through a two-stage process. In the first stage, known as the registration stage, the stimulus is roughly analysed for its relevancy to the well-being of the person, being judged on whether or not the stimulus is positive or negative. The second or allocation stage of the process then allots attention and other cognitive resources to the processing of the stimulus (Cisler et al., 2009). These two stages occur automatically; however, shifts in attention may occur either automatically or strategically, depending on the demands of the task.

In the case of this study, participants are asked to categorise words as being positive, negative, or neutral. Because this is to be done as fast as possible, processing speed is increased at the expense of accuracy. According to the heuristic theory, participants will rely on past exposures to the stimuli to facilitate and speed up this categorisation (Haselton et al., 2005). However, it is unclear whether this increase in speed is caused by increased attention to the preferred stimuli, or whether there is a decrease in the ability to disengage from the preferred stimuli, thereby lengthening response rates to non-preferred stimuli (Cisler et al., 2009). As is noted by Cisler et al. (2009), attentional biases are a robust phenomenon. However, when it comes to the role of cognitive biases in the maintenance of emotional disorders, Hirsch, Hayes, and Mathews (2009) suggest that such a bias towards negative information could be countered by increasing the bias towards interpreting ambiguous words in a benign fashion. For example, studies conducted using both clinical and non-clinical samples have indicated that a more frequent accessing of a benign meaning of ambiguous situations was correlated with a decrease in anticipatory anxiety in socially stressful situations (Hirsch et al., 2009). However, there is no research investigating whether such training may decrease non-clinical emotions or increase the experience of positive emotions, a gap which will be addressed by the current study.

To summarise, there are many types of cognitive biases; some are useful and adaptive in that they enable a person to process information faster, but some may become maladaptive, and may play a role in the development of emotional disorders. Now that cognitive biases have been explored, the definition of cognitive bias modification can be examined.

1.3.2 Origins of Cognitive Bias Modification

As cognitive biases have been found to play a role in several disorders, there have been endeavours to treat such disorders through attempts at modifying or altering existing cognitive biases, often employing computer protocols to implicitly retrain or modify maladaptive biases (Bar-Haim, 2010). Based on these attempts at altering cognitive biases, an experimental paradigm, named cognitive bias modification (CBM), has been developed in recent years. Primarily developed to examine the causality of individual differences in information processing (Lang et al., 2012), CBM has helped to explain the roles between emotion, expectations, and how a situation is experienced.

As a research technique, CBM has proven to be useful in evaluating the emotional and behavioural consequences caused by experimentally manipulating a person to have a particular cognitive bias, and has primarily been used in research documenting individual differences in emotional vulnerability (Hoppitt, Mathews, Yeind, & Mackintosh, 2010; Lang et al., 2012). Initially used as a means by which the causality of anxiety could be experimentally inferred in a laboratory setting, this method became invaluable in helping researchers to develop a better understanding how emotional disorders are formed and maintained. Only more recently has CBM research expanded to include other behavioural and emotional outcomes of cognitive biases (MacLeod, Koster, & Fox, 2009), with a separate branch of CBM, interpretation targeted CBM or CBM-I, aimed at better understanding interpretation biases (Holmes et al., 2009). Using this technique, a person can either be trained to have a specific interpretative bias when processing new stimuli, or CBM-I can be used to modify how the valences of existing stimuli are processed. Although CBM-I is still a very new technique, results thus far have been encouraging, and suggest that, with repeated trials, participants can be trained to have a persistent interpretation bias (Holmes et al., 2009). There is some evidence that through a process of attentional retraining, automatic attentional biases can be eliminated or altered. For example, retraining people to have a negative bias can be important in understanding the aetiology of affective disorders such as depression, whilst retraining a person to have a positive interpretative bias can improve therapeutic interventions (Holmes et al., 2009). For example, in the case of alcohol dependency, studies have indicated that CBM has helped to modify the attentional bias of heavy drinkers, resulting in a decreased urge to drink (MacLeod et al., 2009). CBM has also had success in altering the attentional bias in anxiety, with CBM resulting in the modification of activity in the lateral prefrontal cortex when exposed to emotional stimuli (Browning, et al., 2010).

Whilst some studies claim that people can be trained to interpret stimuli more positively or more negatively (Standage, Ashwin, & Fox, 2010), it was previously not clear whether these findings represented a direct manipulation of attentional bias, or whether the retraining condition altered the mood of the participant, so that a change in affect caused the observed shift in interpretation bias. However, Standage et al. (2010) demonstrated that change in mood state does not have a significant effect on interpretative biases. This finding substantially increases confidence in CBM research, and eliminates changes in mood state being seen as a confounding variable. Thus, recent cognitive modification techniques have made it possible for direct chains of causality to be examined, rather than just exploring associative relationships.

1.3.3 Core model of Cognitive Bias Modification

In terms of underlying neuronal models, CBM can be explained by focusing on biasing signals. There are two biasing signals which guide how attention is allocated to the stimulus, one being inflexible and automatic, and the other being more flexible and strategic (Browning, Holmes, Murphy, Goodwin, & Harmer, 2010). In the first system, the amygdala sends out a signal which allocates attention to the salient stimulus automatically. The second system, which comes into effect when stimuli exert conflicting demands on attention, relies on the production of a signal originating in the prefrontal cortex. In both cases, the signal triggers the association and sensory cortices, and allocates attention more to certain stimuli than to others, thereby making the processing of preferred stimuli faster. Thus, as an intervention, CBM works by mediating the function of the two biasing signals, and in so doing alters the attention which is allocated to the stimulus (Browning et al., 2010). In other words, this attentional retraining changes the activation of the association cortex triggered by an emotionally valenced stimulus. This activation has been manipulated pharmaceutically in the past. For example, antidepressant medication reduces the activation of the amygdala's signal to the association cortex when presented with a threatening stimulus, whilst increasing the activation when the stimulus is positive (Browning et al., 2010). This shows that attentional habit can be changed by influencing how stimuli are initially appraised, rather than altering the habit at a later stage when control processes of a higher order come into effect. Given that this is possible pharmaceutically, the question arises as to whether a similar alteration of attentional habit is possible cognitively, such as through the use of mental imagery. This study is therefore designed to address this question by examining whether mental imagery can affect the reaction rate of participants to emotionally valenced stimuli. But this leads to the question as to what exactly is mental imagery?

1.4 Mental imagery

Mental imagery is defined as using sensory information from multiple modalities to form a mental representation of an image (Holmes & Mathews, 2010). According to Pearson, Deeprose, Wallace-Hadrill, Burnett-Heyes, and Holmes (2013), a mental image can be created in one of two ways. In the first instance, a person can use current perceptual information to create an image directly; as an illustration, if a person were to look at a photograph of a mountain, that person would be able to create a mental image of a mountain, and retain this image even if he or she was to close his or her eyes. The other method through which a person could create a mental image is without the aid of current perceptual information, rather just utilising stored information (Pearson et al., 2013). To continue with the example, in this instance, the person could form a mental image by combining various aspects of stored information about mountains, such as that mountains are high, or that they may be snow-capped.

Mental imagery has been used in clinical settings for several decades. For example, Beck, Emery, and Greenberg (1985) stated that so-called “visual cognitions” could be used in the then new field of cognitive behavioural therapy to alter emotions and cognitive processes. Although initially mainly used for the treatment of traumatic memories, the applications of mental imagery have grown to be more diverse over the years (Holmes, Arntz, & Smucker, 2007). There is a great body of research supporting the importance of the role of mental imagery in a variety of psychological disorders. Negative mental imagery has been found to be central in the formation and maintenance of disorders such as post-traumatic stress disorder, various eating disorders, obsessive compulsive disorder, social phobias, borderline personality disorder and other personality disorders, depression (Holmes et al., 2007), anxiety disorders, schizophrenia, and attention deficit hyperactive disorder (Bar-Haim, 2010), as well as various substance abuse disorders (MacLeod et al., 2009). Yet despite these findings, the use of mental imagery in clinical psychology still does not represent the full potential of mental imagery research (Pearson et al., 2013).

fMRI studies have indicated that the areas of the brain used when engaging in mental imagery are very similar to those used in visual perception (Ganis, Thompson, & Kosslyn, 2004), with a study conducted with reaction time tasks indicating that response rates to both mental images and visually perceived images being comparable (Broggin, Savazzi, & Marzi, 2012). According to Ganis et al. (2004), broadly speaking, both mental imagery and visual perception activated a greater number of common neural structures in the frontal and parietal cortices, and activated fewer common areas in the occipital cortex. In terms of the frontal cortex, both imagery and visual perception activated a number of the gyri, including the inferior and medial frontal gyri, the precentral gyrus, and the anterior cingulate gyrus. Several gyri in the parietal cortex were also activated by both imagery and visual perception, including the left angular gyrus, the postcentral gyrus, and the supramarginal gyrus (Ganis et al., 2004). What was interesting to note was that both mental imagery and visual perception activated the fusiform gyrus in the temporal cortex, a neural structure more commonly associated with facial recognition (Banich & Compton, 2011). Furthermore, several areas of the cerebellum were also activated in both mental imagery and visual perception. Despite the extensive overlap between the areas used in each task, the areas activated during imagery were only a subset of those utilised during visual perception (Ganis et al., 2004). In other words, objects which are imagined mentally elicit the same emotions as if that object were visually observed. Engaging in visual mental imagery triggers the retrieval of perceptual information from long-term memory, allowing the participant to form a subjective impression of the image (Ganis et al., 2004). There is some research to indicate that the emotions evoked in mental imagery are also present in the interpretation of a situation. An attentional bias to threat has been well documented, and a person's threat threshold can be lowered, making that person more attentive to threatening situations (Bar-Haim, 2010, Hoppitt et al., 2010; Burack, Enns, & Fox, 2012). Further studies on anxiety show that, when confronted with a stressful situation, people high in trait anxiety tend to interpret ambiguous stimuli as significantly more threatening when compared to less anxious people. This bias in how a person interprets information leads to an even greater increase in anxiety (Standage et al., 2010), thereby linking interpretation biases and emotions. Similarly, a negative cognitive bias goes some way in explaining the causality of depression, with cognitive theories of depression ascribing the onset and the maintenance of depression to a negative interpretation bias (Lang et al., 2012). A related study examining negative biases showed that people suffering from eating disorders have an attentional bias to cues relevant to food or weight (MacLeod et al., 2009). However, there is less research on emotions which do not manifest in clinical disorders in their extremes, such as those represented by a mildly negative or positive affect. Thus, one of the aims of this study is to examine whether engaging in negative imagery can make a person more sensitive to negative stimuli. Conversely, does exposure to positive mental imagery enhance a person's ability to distinguish positive stimuli? (Please see Section 2.7 for a full review of the aims and research questions of this study)

With regard to the use of mental imagery in CBM, studies have indicated that positive material which is verbally processed has a different effect on mood than positive mental imagery has (Holmes et al., 2009). More recent studies indicate that this finding holds true for both positive and negative mental imagery (Holmes & Mathews, 2010). Holmes et al. (2009) found that participants experienced a more positive mood after having imagined a positive event through mental imagery than after they had processed similar positive information verbally. Other studies indicate that a deeper understanding of negative mental imagery could have a greater effect on reducing suicide rates than is possible with the more typical therapeutic focus on negative verbal thoughts (Holmes et al., 2007). Because of the increased efficacy of mental imagery relative to cues which are processed verbally, mental imagery (when combined with CBM techniques) has the potential to be more effective than traditional CBM techniques which utilise briefly presented visual cues or verbally presented emotionally ambiguous stimuli.

1.5 Stimulus valence

Before looking at stimulus valence, one must first consider how to categorise stimuli as being emotional stimuli or neutral stimuli. But before this can be considered, one must first understand why a person intrinsically reacts to some stimuli, but not to others. From an evolutionary perspective, a person is most likely to attend to a stimulus that evokes emotions which are relevant to that person's survival, which in turn engages the sensory systems which control perceptual processing and attention allocation (Lang & Bradley, 2009), thereby allowing the person to react to the situation. The underlying neural circuitry, known as the motivational circuitry, has two systems: the first of these systems is defensive and is used in the processing of negative affect, whilst the second system is appetitive and deals with positive affect (Lang & Bradley, 2009). Whilst these two systems may be regarded as being separate, there nevertheless is some overlap in the neuronal circuitry on which they are structured, although the degree of this overlap is debatable (Barberini, Morrison, Saez, Lau, & Salzman, 2012). In both systems, once sensory information has been processed by the relevant sensory cortices and projected to the thalamus, the amygdala processes the emotional component of the information (Lang, Bradley, & Cuthbert, 2011). However, although the amygdala forms part of both the appetitive and defensive systems, activation of the amygdala is greater in the defensive system. The defensive system then divides after the information leaves the amygdala, with projections leading to the hypothalamus, which codes for autonomic responses, and to the midbrain, which is involved in the processing of somatic information (Lang et al., 2011). The appetitive system on the other hand has more projections to the orbitofrontal cortex (Barberini et al., 2012).

Emotional stimuli can therefore be defined as being any stimulus which elicits a response from either the defensive or the appetitive motivational circuits of the brain. In other words, an emotional stimulus is a stimulus which prompts either a strong aversive or a strong approach response. For example, a stimulus which may activate the appetitive circuitry could "feast", whilst a stimulus that may activate the defensive circuitry would be "attack". Neutral stimuli, on the other hand, do not have any strong or intrinsic associations with the motivational circuits, and do not elicit any response from this particular circuitry, such as the word "table" (Bradley, Keil, & Lang, 2012). This motivational model of emotion has been proposed in an effort to explain why emotionally valenced stimuli are preferentially processed relative to non-valenced stimuli (Weins & Syrjänen, 2013), and several studies support the notion that activation of the motivational circuitry leads to increased resource allocation as well as dedicated perceptual processing (Bradley et al., 2012). However, there has been some debate as to whether one system is more dominant than the other. In a study done by Lang and Bradley (2009), it was demonstrated that stimuli which are emotionally salient or valenced are preferentially attended to when distracting stimuli are non-valenced. This preferentiality may be explained by the fact that a person relives a particular emotion when processing knowledge pertaining to that emotion, as is pointed out by Niedenthal, Winkielman, Mondillon, and Vermeulen (2009). In other words, when deciding whether a stimulus is negative or positive, the person will rely on previous emotions which have been evoked by the stimulus. The idea that emotionally valenced stimuli are processed faster than non-valenced stimuli is contained in the notion of motivated attention, a bottom-up type of attention which is driven by the emotional features of the stimulus (Weins & Syrjänen, 2013). Thus, motivated attention refers to the increase in attention given to emotionally valenced stimuli which are relevant to a person's biological survival.

Now that it has been clarified that stimuli receive differing amounts of attention, it is important to expand on what is meant by the term "stimulus valence". The valence of a stimulus can range from positive to negative (Lithari et al., 2010). For example, it could range from pleasure to disgust. The valence of a stimulus has been found to influence several cognitive processes. For example, memory encoding, perceptual processing, the amount of attention dedicated to a particular stimulus, and how a problem is solved, are all influenced by how positive or negative the stimulus is perceived to be (Sakaki, Niki, & Mather, 2012). Furthermore, the greater the emotional valence of the stimulus, the greater the attentional resources allocated to that stimulus (Kuhbandner, Hanslmayr, Maier, Pekrun, Spitzer, Pastötter, & Bäuml, 2009), meaning that highly positive or highly negative stimuli will receive more attentional resources than neutral stimuli. The valence of a stimulus is indeed such an important feature that positively valenced words enhance hemispheric asymmetries, whilst negatively valenced words may actually reverse existing hemispheric asymmetries (Alfano & Cimino, 2008). This has been hypothesised to be caused by the asymmetrical presentation of arousal across the hemispheres. Alfano and Cimino (2008) found activation of the left hemisphere when positively valenced words were presented to participants, whilst the presentation of negative stimuli activated the right hemisphere, thereby suggesting that any advantage which the left hemisphere in processing language is reversed when the valence of the stimuli is negative.

Nevertheless, care must be taken when drawing assumptions from the conclusion that the valence of a stimulus affects how the stimulus is processed. Just because the processing of emotionally valenced stimuli is enhanced does not necessarily mean that the identification process is increased due to greater accessibility to information about the stimulus. Zeelenberg, Wagenmakers, and Rotteveel (2006) instead propose that emotionally valenced stimuli are implicitly biased, thereby making their identification easier. In other words, due to their emotional significance, emotionally valenced stimuli are perceived and reacted to faster than neutral stimuli in much the same way as implicit priming works; this has been shown in a number of paradigms, including an attentional-blink and a two-alternative forced-choice paradigm, and can also be seen when analysing event related potential components (Zeelenberg et al., 2006). Furthermore, this bias may either be a processing bias or a resting level bias. In the first case, a processing bias can be said to occur when non-discriminative information about a stimulus has a higher probability of being interpreted as either emotionally relevant or not. Conversely, a resting level bias occurs when one type of stimulus, such as a neutral stimulus, has a resting level which requires more activation than another type of stimulus, such as an emotional stimulus (Zeelenberg et al., 2006). For example, this model would propose that an emotionally salient word like "coffin" has a higher resting level than a neutral word such as "wood", which results in less activation needed to identify "coffin", which in turn leads to a faster recognition of the word "coffin". In an effort to see how much of the faster processing of emotionally valenced stimuli was due to bias and how much was due to enhanced processing, Zeelenberg et al. (2006) devised a means of untangling the two effects. Their findings showed that the effect of enhanced processing was much greater than that of any inherent bias. This may indicate that a bias may only affect the processing of emotional stimuli if the stimuli are visually similar. However, their observations are clearly indicative of the fact that emotionally valenced stimuli receive enhanced processing resources when compared to neutral stimuli. (Please see section 2.6 of Chapter 2 for a discussion of the base assumptions concerning cognitive architecture made in this study).

With regard to the processing resources allocated to stimuli, there are other factors which must also be considered. Kuhbandner et al. (2009) report that a person's affect can influence the style in which that person processes information, with a negative mood resulting in a bottom-up processing style, and a positive mood making a top-down processing style more likely. As biases are seen as a higher cognitive function (Caverni et al., 1990), it can be hypothesised that biases are more prominent when a top-down processing style is engaged, although this remains unclear. Likewise, mood can also affect the brain's alpha wave frequency, thereby affecting how stimuli are consciously perceived. Similarly, findings show that a person's processing style can affect that person's mood and can play a significant role in mental health (Lang et al., 2012). However, some questions have arisen as to whether biases cause the emotional state, or whether the emotional state causes the biases (Hoppitt et al., 2010). Thus, a further aim of this study is to clarify this point. A neutral condition will be tested first to see if any of the participants have pre-existing cognitive biases. As this condition tests for pre-existing biases, assuming that there are no pre-existing biases, any biases observed in the two experimental conditions can then be regarded as a direct result of the mental imagery, thereby allowing claims of causality to be made. In terms of processing style, Kuhbandner et al. (2009) state that as bottom-up processing occurs faster, people are faster at recognising negative rather than positive stimuli. On the other hand, Hoppitt et al. (2010) claim that the healthy, non-clinical population has a slight bias in perceiving positive stimuli as this helps to shield them from negative emotions. The current study will shed some light on this difference in opinion, as the neutral condition of the study is aimed at identifying any pre-existing biases. Thus, the results of the current study will be able to provide evidence to resolve this conflict.

At this point, it is clear that emotionally valenced stimuli are given greater attentional resources than non-valenced stimuli, but this still leaves the question regarding the means through which this occurs. How attention is allocated to emotionally charged stimuli is often explained using the biased competition framework (Browning et al., 2010). According to this model, biasing signals can be seen to influence attention to either be focused towards or away from the stimulus in question. The perceived salience of the stimulus is linked to bottom-up processing by the amygdala, which plays a role in directing attention towards the stimulus. The anterior cingulate cortex and the lateral prefrontal cortex, on the other hand, detect and resolve processing conflicts, and employ a top-down method of processing which maintains attention towards a particular stimulus, even when distracting stimuli are present (Browning et al., 2010). In other words, the amygdala-based system orients attention to a stimulus, whilst the anterior cingulate cortex and the lateral prefrontal cortex play a role in the maintenance of attention to the stimulus. Thus, based on these neuroanatomical models, negative attention biases may arise due to disruptions in either pathway, whilst a positive attention bias is reflected by increased activity in the amygdala (Browning et al., 2010). For the sake of clarity, this is diagrammatically represented in Figure 1.

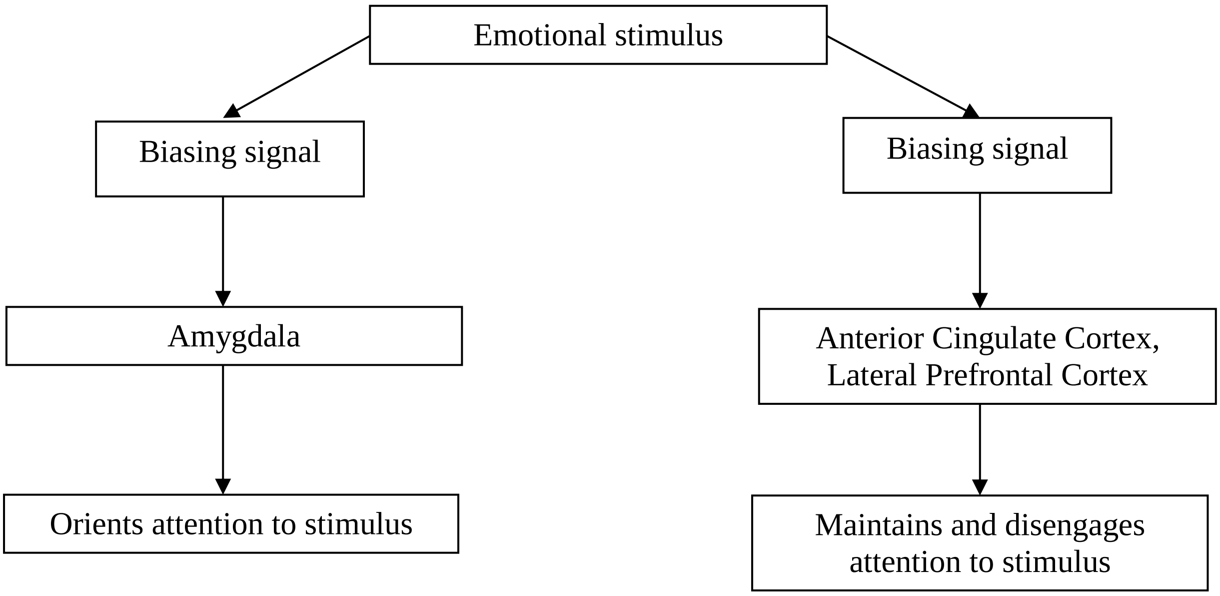

Figure 1.1: Diagrammatic representation of the Biased Competition Framework

Browning et al. (2010) have further hypothesised that emotional disorders may be primarily caused by a shift in the preferential reactivity to valenced information of the two systems, as opposed to a change in the function of the systems. Put another way, in order for an intervention to be successful, the intervention should be targeted at changing the attentional preferences of the systems, rather than trying to affect the efficacy of the systems.

The underlying hypothesis of this study, namely that positive mental imagery would result in a faster reaction rate to positive stimuli, and that negative mental imagery would speed up recognition of negative stimuli, are based on the take-the-best algorithm. This algorithm employs a decision tree structure, which holds that when making a decision, if only one possibility is recognised, then that possibility will be selected. If all possibilities are recognised, then a salient cue identified with each of the possibilities is examined. This will continue until one possibility will have more salient cues than another (Haselton et al., 2005). The hypothesis of the current study states that by engaging in positive mental imagery, the imagery would make positive stimuli easier to recognise, which would enable the participant to categorise a positive stimulus as being positive faster than they would be able to categorise negative or neutral stimuli. In other words, when having to categorise a stimulus according to its valence, only one possibility is correct for each stimulus, thereby increasing the likelihood that that particular possibility will be selected. Conversely engaging in negative mental imagery will increase the recognition time of negative stimuli, but not positive or neutral stimuli, again allowing only one possibility to be recognised and therefore selected.

To summarise, when a participant is presented with a stimulus, the stimulus is roughly scanned for its biological relevance. If the stimulus is not relevant, it is not processed further. On the other hand, if the stimulus is deemed to be relevant, a decision is made on whether the stimulus is negative or positive, and based on this information, the stimulus is then allocated a certain amount of attention. The more relevant the stimulus, the more attention it receives, and the faster the stimulus can be processed. As information processed through mental imagery has been shown to evoke more emotions than the same information processed verbally, this study hypothesised that mental imagery would have an effect on attentional biases by increasing the relevance of the stimulus, thereby increasing the processing rate of relevant stimuli.

1.6 Outline of chapters

The contents of this report have been split into five chapters. Chapter 1 has introduced the topic under consideration, provided an overview of the context of the problem, outlined the aims of the study, and has clarified the key concepts of the study. The second chapter introduces and appraises the fundamental constructs which underlie the study, and presents a critical review of previous literature in the field upon which the current hypotheses are based. Chapter 2 also critically examines the design of previous CBM research, highlighting how the current study addresses the short-comings of previous research. Chapter 3 summarises the research method, sample, measurement instrument, and the data analysis methods of the study. The results obtained from the data analysis methods are then provided in Chapter 4, with visual representations and statistical analyses of trends in the data where relevant. Chapter 5 discusses the implications of these results, and what inferences can be drawn from them. The chapter also contains information regarding the limitations and contributions of the current study, as well as recommendations for future research, before closing with a concluding statement.

CHAPTER 2
THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Chapter 1 provided a contextualised overview of the research problem, introduced the aims of the current study, and elucidated the key concepts underlying the hypotheses. The purpose of this chapter is therefore to expand on this by demonstrating how these key concepts fit together to form the topic being studied. In addition, a thorough examination of past research will be chronicled, including the strengths and weaknesses of previous studies. To begin with, research pertaining to the reaction rate to emotionally valenced stimuli will be reviewed, before moving on to the more central issue of how mental imagery affects reaction rates in general. After this issue has been fully examined, the fundamental and most prominent topic concerning how mental imagery affects the reaction rates to emotionally valenced stimuli will be explored. Once these issues have been comprehensively reviewed, a critical assessment of past research and the implications of this evaluation for the current study will then take place.

2.1 <u>Reaction rate to emotionally valenced stimuli</u>

For the sake of this dissertation, the terms "reaction rate", "response rate", and "reaction time" are used interchangeably. Before going on to look at how reaction rates are influenced by emotionally valenced stimuli, it is important to first have a better understanding of how it is that such stimuli are processed relative to other stimuli. The emotional valence of a stimulus is one of the most basic, yet most important aspects of stimulus processing. Emotional stimuli play a vital role in informing how a person effectively interacts with the environment, with much evidence pointing to the fact that behaviour may only be successful if salient emotional stimuli are detected and responded to (Gianotti, Faber, Schuler, Pascual-Marqui, Kochi, & Lehmann, 2008). For example, if a person is presented with a stimulus which is either threatening or rewarding, the stimulus triggers the neural motivation circuitry previously discussed, which orients the person to the stimulus, and facilitates attention towards the stimulus. This in turn assists the person in choosing and implementing an appropriate response to the stimulus (Bradley et al., 2012). Several researchers have shown that the emotional significance of a stimulus is automatically processed by a person, often skipping the more elaborate cognitive processing prompted by non-emotional stimuli; indeed, information about the emotional content of a stimulus has been found to be accessible at the primary stages of stimulus processing (Phelps, 2005). In other words, before a person is even consciously aware of a stimulus, the emotional relevance of that stimulus has already been processed. This unconscious processing of emotion affects whether or not a person becomes aware of the stimulus and identifies it, and also directs how much attention is initially allocated to the stimulus in question. In this way, the initial processing of the stimulus has a great impact on the later processing stages (Phelps, 2005).

Once the initial processing of a stimulus is complete insofar as the stimulus has been identified and attention has been allocated to the further processing of the stimulus, then the emotion-evoking aspect of the stimulus is examined. As is noted by Weins and Syrjänen (2013), stimuli vary in their ability to elicit a person’s attention, with stimuli which are judged to be more important capturing attention more than stimuli deemed to be less important. Of the various stimuli, emotionally valenced stimuli are more relevant to a person’s survival, and are therefore intrinsically more important than non-emotionally valenced stimuli. According to Greenberg, Tokarev, and Estes (2012), a person remembers and recognises words which have an emotional valence better than neutral words, and is also faster at recognising emotionally charged words. Multivariate studies have shown that the manner in which an emotional stimulus is categorised is dependent on two dimensions, namely valence and arousal (Gianotti et al., 2008; Grider & Malmberg, 2008), where valence is defined as the subjective emotional value of a stimulus, and arousal is defined as the subjective intensity or excitement caused by the stimulus. Both valence and arousal are thought to exist along continuums; in the case of arousal, the continuum runs from a state of calmness to a state of excitement, whilst the two extremes of the valence continuum are pleasant and unpleasant (Gianotti et al., 2008). These two dimensions are not entirely separate: Grinder and Malmberg (2008) report that the two dimensions are positively correlated, with more highly valenced stimuli being more arousing, and vice versa. Responses to stimuli are dependent on where the stimuli fall on these two continuums, with fMRI studies indicating that each of the two dimensions have their own separate neural network. In a study done by Gianotti et al. (2008), it was found that once a stimulus word was presented, it took an average of 118 milliseconds for information about the valence of the stimulus to be inferred by the participant. However, information about the arousal of the stimulus was only extracted 266 milliseconds after the onset of the stimulus presentation.

These results clearly indicate that information about the valence of a stimulus precedes information about the arousal dimension of the stimulus.

It has been well documented that the amygdala is, to a large extent, responsible for the processing of emotional information, especially when the information is fear related. However, neuroimaging studies have shown that amygdala activation is arousal dependent (Gianotti et al., 2008). In other words, the amygdala only becomes activated if stimuli are highly arousing, regardless of their valence. Furthermore, the amygdala is also involved in emotional memory, and modulates the amount of arousal that is allocated to hippocampal-dependent memories, where hippocampal-dependent memories can be defined as those memories which are explicitly expressed and are consciously available (Phelps, 2005). The implications of these findings are that both the positive and negative emotionally valenced stimuli presented in this study would have caused the activation of the amygdala, which would have then allocated attentional resources to relevant stimuli.

Although based on inconsistent findings, research shows that there is interplay between processing of emotional information and various cognitive processes, with each affecting the other (Kousta, Vinson, & Vigliocco, 2009; Kellermannet al., 2012). The emotions experienced by a person whilst performing goal directed cognitive tasks may either facilitate or impair the person's performance, depending on which cognitive process is being utilised, what the valence of the stimuli is, and how vulnerable the person is emotionally (Kellermann et al., 2012). The effects of emotions, however, have been shown to be dependent on the cognitive load of the task being performed (Kellermann et al., 2012). In terms of the current study being conducted, the mood state of participants will play a very small role, as not only is the cognitive load of the study minimal, but the sample will also be drawn from a non-clinical population, thereby ensuring that the emotional vulnerability of the participants is low.

Now that the mechanisms through which emotional stimuli are processed are understood, it is time to look at how various factors influence this processing to produce variations in reaction rates. Gender and age are two such influencing factors. Although the amount of research on gender differences in emotions is limited, it has been found that gender differences exist both in how men and women process emotions and in how they react to emotions (Lithari et al., 2010). In general, these findings suggest that females are more responsive to emotional stimuli than males, particularly if the stimuli are related to danger. In terms of ageing, in the field of developmental psychology it is a well-established fact that there are differences in the speed-accuracy trade-off made by younger and older adults. From a generalised point of view, on the one hand older adults typically make more accurate decisions than younger adults, but on the other hand, younger adults are faster at making decisions than their older counterparts (Starns & Ratcliff, 2010). In the context of the current study, this finding would imply that older adults may take longer to categorise the stimuli than younger adults, thereby resulting in longer reaction times. However, one factor which influences response time is boundary separation. According to this construct, the speed at which a decision is made is dependent on the amount of information needed to make this decision (Starns & Ratcliff, 2010). In other words, the greater the amount of evidence which must be accumulated in order for the alternative choice in a decision to be accepted, the slower the decision is made to avoid jeopardising the accuracy of the decision.

A further factor which affects reaction rate is the cognitive demands of the task being performed. Neuroimaging studies have shown that the amygdala becomes activated during the implicit processing of salient stimuli whilst the orbitofrontal cortex appraises the strength of the valence of the stimulus (Kellermann et al., 2012). The higher the cognitive demands of the task being performed, the more suppressed the activation in these two areas is. As both emotional and non-emotional stimuli must compete for attention, it had previously been assumed that increased cognitive demands caused participants to miss irrelevant stimuli (Kellermann et al., 2012). However, more recent studies suggest that the increased cognitive demands of a task lower the reactivity of the affective network to less relevant emotionally valenced stimuli, thereby increasing the amount of attentional resources which are available for the processing of more relevant emotional stimuli (Kellermann et al., 2012). As the cognitive load of the current study is small, the reactivity of the affective network will not have to be suppressed, resulting in unaffected processing of the emotional stimuli.

In addition to this, studies have indicated that arousal is greater for stimuli which are potentially dangerous (Lithari et al., 2010), indicating that the inherent attributes of a stimulus can affect the reaction rate of a person to that stimulus. For example, if a stimulus presents a threat to the person, the attention allocated to that stimulus is greater than the attention allocated to less threatening stimuli. Kousta et al. (2009) theorise that this may be because recognising and therefore avoiding a threatening stimulus is more valuable to a person's survival than recognising and approaching a rewarding stimulus. According to the automatic vigilance model of emotion, negatively valenced stimuli automatically trigger a mechanism which allocates attentional resources to the negative stimulus at an earlier point in time than to other stimuli (Kousta, Vigliocco, Vinson, Andrews, & Del Campo, 2010). This model has, however, been contested, with other researchers claiming that negative stimuli are not allocated more processing resources than other stimuli, but rather that negative stimuli capture attention for longer than do other stimuli, which may cause negatively valenced stimuli to be processed more slowly than other stimuli in certain tasks. A meta-analysis conducted on relevant research concluded that much of this slowing of negatively valenced stimuli could be attributed to lexical characteristic differences between studies (Kousta et al., 2010). In other words, characteristics of words such as how frequently a word is used and the length of the word affect the rate at which a stimulus is responded to. However, at the same time, other studies have indicated that stimuli which are associated with rewarding outcomes are also allocated more attention than non-rewarding stimuli (Lithari et al., 2010; Bradley et al., 2012). In an effort to resolve this conflict of opinions, Kousta et al. (2010) designed a study to address the weaknesses in previous research designs. Their findings indicated that both negatively and positively valenced stimuli are processed more quickly than neutral stimuli. These results have been replicated on numerous occasions, and it is now a commonly accepted fact that both positive and negative stimuli elicit not only a faster response rate than neutral stimuli, but also that emotionally valenced stimuli are more accurately identified than neutral words, regardless of their polarity (Zeelenberg et al., 2006). As the stimuli used in this study are chosen because they present either a threat or a reward to a person's biological well-being, both positive and negative stimuli should been allocated similar amounts of attention. This effect of attention allocation has also been seen in studies on anxiety, with anxious people recognising threatening stimuli faster due to the increase in attention which is allocated to threatening stimuli, thereby allowing such stimuli to be processed faster than other stimuli (See, MacLeod, & Bridle, 2009). This indicates how an attentional bias may result in the faster processing of certain stimuli relative to others. As indicated previously, this central assertion underlies the hypotheses of the study, which aims to uncover whether such a cognitive bias could also be induced through the use of mental imagery.

Reaction rate to emotionally valenced stimuli is also affected by the amount of anxiety being experienced by the person as they encounter the stimuli. One interesting finding has indicated that anxiety may reduce the amount of available working memory capacity, potentially due to the anxious person engaging in excessive worrying (Hirsch et al., 2009). This may result in reduced cognitive resources being available for the processing of new information, which may in turn reduce the reaction rate of that person to non-threatening stimuli (Hirsch et al., 2009). However, as this study relies on a non-clinical sample, it can be assumed that such a negative bias will have no influence on the results of the study.

To sum up, there are several factors which influence a person's reaction rate to emotionally valenced stimuli. Of these factors, some were inapplicable in the context of this study, as they are only observed in clinical populations, or are only seen when the cognitive load of a task is high. However, some factors, such as highly valenced stimuli and gender differences are relevant in the context of this research, and will thus be further explored, and the findings will be described in chapter 4.

2.2 The effects of mental imagery on reaction rates

The previous section of this chapter has shown that reaction rates to stimuli are influenced by various factors, as well as documenting in detail how emotionally valenced stimuli are processed and reacted to. However, a more central question arises: how does mental imagery differ from information processed through other modalities in terms of reaction rates? Does mental imagery have the same effect on reaction rates as information processed verbally or visually? This question and other related questions will now be addressed in this section.

Firstly, how does mental imagery affect cognitive processes compared to information processing in other modalities? Recent studies have indicated that mental imagery has different and more pronounced cognitive outcomes when compared to verbal processing of the same material. For example, mental imagery can be used to increase positive affect and to decrease anxiety, and has also been found to induce a robust interpretative bias (Holmes et al., 2009). In fact, in one study, positive verbal instructions lost their efficacy over the course of the training sessions, and even began to enforce a negative interpretation bias, a result not observed in the mental imagery condition (Holmes et al., 2009). In terms of the effects of mental imagery on reaction rate, studies have shown that mental imagery has a greater effect on reaction rate than verbal instructions, although these same findings suggest that this effect is even larger when using pictures of stimuli as opposed to mental images of the same stimuli. It has been proposed that this may be because pictures share a greater number of perceptual and sensory properties with the objects they represent than do mental images of the same object (Bradley et al., 2012). This finding is in line with those reported in section 1.4 of Chapter 1, which suggest that the brain areas activated in mental imagery are a subset of those activated in visual perception (Ganis et al., 2004). Pearson et al. (2013) state that the vividness of the mental image is also dependent on the attentional resources which a person has at their disposal, suggesting that the vividness of a mental image may differ form one person to another, depending on the availability of attentional resources. However, as one of the aims of this study is to test the potential of new therapeutic methods which can be delivered without the presence of a therapist, it is essential to test a method which relies on as few outside resources as possible. Based on this logic, it is seen to be far more effective to study the effects of mental imagery on the modification of cognitive biases, as mental imagery can be engaged in at virtually any point during a person's daily routine.

Thus, although not as effective as using pictures, mental imagery has been found to cause faster reaction rates than verbal processing. This may be due to the fact that mental imagery has a perceptual correspondence which is lacking in verbal information processing. In other words, when using mental imagery, sensory experience is directly accessed, making the imagery more realistic by simulating real-life perceptions; verbal information processing, on the other hand, does not access this sensory experience, resulting in poorer emotional activation (Holmes et al., 2009). The neural circuitry used when engaging in mental imagery is very similar to the circuitry used when remembering past events or envisioning what the future would be like (Schacter, Addis, & Buckner, 2007), and it has been suggested that this difference between mental imagery and verbal processing can explain why mental imagery causes faster reaction rates. Furthermore, a difference between information processed verbally as opposed to information processed through the use of mental imagery is that cognitive bias modification retraining using verbal instructions was actually found to lower positive affect over time, as well as to increase the state anxiety of the participants (Holmes et al., 2007). As the current study is conducted for its potential contributions to therapeutic techniques, it is important to avoid such a decrease in positive affect and increase in anxiety. However, with regard to reaction rate, it must be borne in mind that both positive and negative mental imagery, such as daydreaming or flash-backs respectively, are both more absorbing than similar information processed verbally, and may therefore take longer to process than verbal information (Holmes et al., 2009). Because of this, the current study will allow participants to engage in the mental imagery conditions for as long as the participant desires, thereby ensuring that the reaction rates to emotionally valenced stimuli are only measured once the participant had completed the imagery condition.

So far, it has been shown that mental imagery results in faster recognition of emotionally valenced stimuli when compared to verbal processing. A further factor which may influence how mental imagery affects reaction rate is the personality of the person engaging in the imagery. For example, fMRI studies have indicated that participants differ in the degree of vividness which their mental images have, as indexed by differences in neuronal activation (McDougall & Pfeifer, 2012). Not many studies have been done on how personality differences affect mental imagery, yet those which have been carried out have yielded some interesting findings. For example, some studies suggest that introverted people may be more sensitive to mental imagery than more extroverted participants, although the results of such studies are inconclusive. Conversely, other studies have shown that extroverts subjectively report more vivid images than introverts, although this may be due to introverts being less impulsive in their reports of vividness (McDougall & Pfeifer, 2012). In other words, if the mental imagery must occur simultaneously with other tasks which involve visual suppression, then the mental images will be less vivid, and may have less of an effect on other cognitive processes than if the images were vivid. However, as this study presents no conflicting tasks during the imagery conditions, it can be assumed that the mental imagery will be rich, as there are no suppressing variables.

Mental imagery, and consequently the reaction rate to mental imagery, is also affected by the concreteness of a word. A concrete word may be defined as any word that is representative of an object that can be perceived through other modalities, such as touch and sight. If the word being presented is not observable through other modalities, then it is considered to be an abstract word. An interesting finding shows that the concreteness of the word being imagined has an effect on how information is retrieved from memory (McDougall & Pfeifer, 2012). Concrete words which can easily be visualised, such as “door”, have been found to be processed faster than abstract words, such as “pride”, which are not associated with one particular object or image. Consistent with such findings, imaging studies have shown that, whilst there is some neuronal overlap, concrete and abstract words are each processed by distinct systems (Binder, Westbury, McKiernan, Possing, & Medler, 2005). According to dual coding theory, there are two ways in which memories can be coded or represented. The first representation semantically organises verbally associated words. The second system, which is linked to the first system by referential connections, creates representations of nonverbal and perceptual experiences, and codes these as images (Paivio, 1991). Thus, if a person is presented with a concrete word, the word will first trigger the activation of a verbal representation, and then will activate an imagery representation of the word via the referential connections to the second system. If, on the other hand, the word which is presented to the person is an abstract word, then the word will primarily only activate the verbal representation of the word, as imaginal representations are far less robust. McDougall and Pfeifer (2012) have used this theory to explain that as concrete words have stronger imaginal representations, they are processed faster than abstract words. It must, however, be noted that this concreteness effect disappears when concrete and abstract words are presented in sentences or are otherwise contextualised. In an attempt at resolving this short-coming, context availability theory was proposed. According to this theory, concrete words are processed faster as they have a greater store of relevant world knowledge in several modalities. Conversely, abstract words have fewer connections to relevant contextual knowledge, resulting in reduced access to semantic information, and thus take longer to process (McDougall & Pfeifer, 2012). Nevertheless, regardless of which theory is adopted, as this study only presents isolated words, it can be assumed that the concreteness effect, and by extension both the dual coding theory and context availability theory, are still applicable to the current research. It has also been found that ambiguous words have fewer contextual associations, and therefore take longer to process than unambiguous words (McDougall & Pfeifer, 2012). As all words used in this study are unambiguous, however, it can be assumed that this has no ramifications for the current study.

To conclude this section, past research supports the notion that mental imagery results in faster reaction rates to stimuli than if the same stimuli are presented verbally. Conversely, the studies explored in the previous section established that reaction rates are biased in favour of emotionally valenced stimuli relative to non-valenced stimuli. This leads to the central question of the current research: namely, what is the effect of mental imagery on the reaction rate to emotionally valenced stimuli?

2.3 The effects of mental imagery on reaction rates to emotionally valenced stimuli

Whilst there is a plethora of research which has been conducted in each of the fields of mental imagery, reaction rates, and the emotional valence of stimuli, there is very little research which has been done on the intersection of the three aforementioned fields. As CBM is still a very new field, many of the factors which influence the formation and modification of cognitive biases have as yet not been explored. Indeed, addressing this absence of information is one of the primary contributions of the current study. To wit, there have been no studies on how mental imagery affects a person's reaction rate to emotionally valenced stimuli, or how this could be used to modify cognitive biases.

Nevertheless, there is some research that has built a foundation on which to base research on the effects of mental imagery on the reaction rate to emotionally valenced stimuli. As stated in Chapter 1, one of the aims of this study is to help provide a framework on which a new therapeutic method aimed at the non-clinical population could be based. In other words, this study aims to explore whether CBM could be coupled with mental imagery to elicit or enhance positive affect in a non-clinical population, possibly as a preventative measure. As is stated by Levens and Gotlib (2012), having an optimistic outlook on life is linked to adaptive psychological adjustment, whilst pessimism may lead to psychological maladjustment. Previous research has indicated that attention and information processing has an effect on the optimism of a person. This therefore suggests that the early stages of the processing of an emotionally valenced stimulus are vital in influencing whether that stimulus will be assigned a positive or negative meaning. In other words, being pessimistic or optimistic may influence how information is updated in working memory, thereby affecting the association formed between the stimulus, and the information evoked by the stimulus (Levens & Gotlib, 2012).

When performing tasks, the content being held in working memory changes. New input gets combined with previously stored material, and both types of information are typically manipulated. For example, if a person were asked to perform a mental calculation, then working memory would be necessary not only to keep the given numbers in mind, but these numbers would also have to be manipulated in order to establish what the answer is. Working memory also updates, referring to the process through which currently represented and previously stored information is modified to accommodate new information (Levens & Gotlib, 2010). How emotionally valenced information is processed in the working memory is an elaborate process, typically involving the activation of the long-term memory store combined with updates of new inputs. The duration of the activation is also important, as representations which are active for longer receive increased processing resources when compared to representations which are less active (Levens & Gotlib, 2010). So-called maladaptive rumination occurs when elaboration of negative content being held in the working memory is not reduced, and which may play a part in the formation of depression. In this case, the depressed person is slower at disengaging from negative information, which results in lengthier activation of the negative material, which in turn leads to more elaborate processing and increased cognitive resources being dedicated to the maintenance of the negative information, at the expense of positive information. The opposite of this is adaptive mood repair, in which positive material is activated and elaborated in working memory, whilst updating negative information to be more positive (Levens & Gotlib, 2010). It is exactly this maladaptive rumination and adaptive mood repair which are to be induced respectively by the negative and positive mental imagery conditions of this study.

2.4 Critical assessment of past research

Having considered previous research conducted in and around the fields of CBM and mental imagery, as well as how these findings contribute to the current research questions, it is now important to reflect on the weaknesses of past research. When viewing this past research in its totality, two main critiques present themselves: the subjective, self-reported measures often relied on, and the generalizability of the samples used. Both of these critiques will now be further examined.

2.4.1 Self-report data

The first major critique of past research in the field of CBM concerns the nature of the results gathered. Despite the important potential contributions which CBM has to offer, only a limited amount of research on CBM has been published (MacLeod et al., 2009). Considering that CBM is still a relatively new field, such a limited amount of research is understandable. However, of these relatively few publications, the majority of the studies employ subjective measures using emotionally ambiguous stimuli. Due to this use of ambiguous words, the results of these studies are not necessarily generalisable to a larger population, as ambiguous words may have different emotional valence for different people (Hoppitt et al., 2010). However, whilst such findings are important in furthering the understanding of how a person interprets an emotionally ambiguous stimulus, this has nevertheless restricted the potential of the field. For example, although biases are prevalent in many emotional disorders, the exact mechanisms of how such biases influence the maintenance of the disorder varies from one disorder to another (Lang et al., 2012). Thus, whilst subjective measures may show that biases differ from one disorder to another, such findings are nevertheless limiting as they do little to inform models of how such disorders may arise. Thus, clearly lacking in the field of CBM are studies based on objective methods of quantifying the effect of bias modification on how stimuli are perceived.

2.4.2 Clinical populations

The second major critique of much of the current research in CBM concerns the population from which the research samples are drawn. The greater part of CBM studies has been conducted using a clinical sample, and whilst this does much to further the understanding of emotional disorders, these results lack generalizability. In other words, findings from studies which used a clinical sample are applicable only to other populations which share the same features as the sample group. Whilst such findings may do much to improve the understanding and treatment of clinical disorders, a lack of normative research still represents a limitation of the potential scope of CBM research. To illustrate this point, normative research in the field of CBM could result in increased quality of life in a normative or non-clinical population, or could be used in dealing with non-clinical negative affect, or could be used in establishing measures aimed at identifying those individuals who are at risk of developing an emotional disorder, but who do not as yet meet all the necessary criteria for such a diagnosis. Such normative research may even play a role in the development of preventative therapeutic interventions aimed at individuals at risk of developing an emotional disorder. Thus, to fully take advantage of all the potential and possibilities of CBM research, it is important to go beyond studying clinical samples.

In addition to this, most of the research done in CBM has focused either on an attentional bias found in anxiety disorders, or on a negative interpretation bias found in depression (MacLeod et al., 2009). Such previous studies have been able to show that threat-related attentional retraining has been successful in reducing anxiety in people (Bar-Haim, 2010). However, what these studies have failed to demonstrate is whether this reduction in anxiety only occurs in response to threatening stimuli, or whether the control process which is induced is relevant to a wider range of stimuli. In other words, CBM research has focused on the effects of negative biases in clinical populations, with little research being conducted on the effects of positive biases, be it in clinical or non-clinical populations.

There is a further disadvantage of using samples drawn from clinical samples; namely, the validity of such results may be questioned. The results drawn from clinical samples may not necessarily be completely valid, as such studies often do not control for confounding factors which may have played a significant role in obtaining such results (Browning et al., 2010). For example, if a participant suffering from depression goes through a bad phase at the time of measurement, a greater negative bias will be observed. However, this bias would be due to the depression rather than the effect of the attentional retraining task. Thus studies which were conducted using clinical samples yield results which are not entirely valid and which are not generalizable to either the general population, or even to clinical populations with different disorders from those in the sample. Therefore, the contributions of much of the existing CBM research are limited, resulting in the need for more objective research conducted on non-clinical populations.

2.5 Implications for the current study

Given that the use of clinical sample groups and the use of self-report measures have limited the potential findings of a large proportion of previous CBM studies, the current study is designed in part to address these weaknesses. The current research will therefore draw its results from a non-clinical sample using an objective instrument which is specifically designed to address the research question under study. The implications of this are now more fully explored.

2.5.1 Objective report

The current study will take a step towards addressing the dearth of objective research. As indicated above, many of the studies done in the field of CBM use subjective self-report measurements, and are of indeterminate validity as results may be due to demand effects rather than to the intervention (MacLeod et al., 2009). In addition to this, of those studies which do use a more objective measure, some did not utilise customised assessment procedures which were directly relevant to the symptomatology being studied: these studies instead employ measures which were not perfectly suited to the topic being considered (MacLeod et al., 2009). This study therefore addresses these limitations by using an objective measure to accurately gauge the effects of mental imagery. Furthermore, rather than taking an existing measure and trying to build the rest of the study around that measure, this study will utilise an assessment instrument which is specifically designed to best test the hypotheses directly and accurately, thereby ensuring that the instrument is completely pertinent to the research questions being addressed.

2.5.2 Normative population

The second methodological weakness of many CBM studies concerns the use of clinical samples. As this study uses a non-clinical sample, the results of this study are more externally valid than those of previous studies, and may be generalised to a much wider population. This is an important contribution to the field of CBM, as claims of causality cannot be inferred when using a clinical population due to the possible confounding factors inherent in such a population. Thus, the results of this study will provide findings which are more generalizable to the wider population than previous research done using clinical samples.

In response to the fact that most CBM research to date has focused on negative cognitive biases, the current study is designed to also study positive biases, as these may be of potential therapeutic benefit. Thus, this study is unique in that it focuses not only on negative attention biases, but also on positive attention biases and how these affect processing speeds, and therefore reaction rates. Put another way, this study does not emphasise dysfunction, but rather aims to uncover how dysfunction may arise as well as looking at how normal function can be optimised.

Finally, before going on to examine the method underlying this study, the theoretical assumptions underlying the study will be explored, and the specific research questions being addressed will be detailed.

2.6 Overview of the theoretical assumptions made

As has previously been mentioned, this study makes some core assumptions about cognitive architecture and about how people interact with the world around them. The purpose of this section is to set out these premises clearly.

One of the main premises of this study concerns how people interact with their environment. This premise assumes that a person's expectation of a situation makes that person more likely to interpret the situation accordingly. For example, a neutral event such as going to a place for the first time may be influenced by one's expectations. Thus, if a person hears that the people in a particular town are unfriendly, that person may go to this town for the first time with the expectation of meeting unfriendly people, and may rate the townspeople as being more unfriendly than the person would have otherwise rated the friendliness of the townsfolk. In other words, a person's expectations may result in the person seeking out evidence to confirm their expectations whilst ignoring any evidence that goes against their expectations. In the context of the current study, this would mean that by altering what a person expects from a particular situation, one would be able to alter how the person perceives the situation. This assumption underlies the main hypothesis of the study, namely that by invoking a cognitive bias, one alters the way that emotionally valenced stimuli are perceived and responded to. This assumption is supported by previous clinical studies which have shown that people suffering from emotional disorders, such as depression and anxiety disorders, have thinking styles heavily influenced by cognitive biases, such as negative interpretation biases (Holmes et al., 2009).

A second assumption made in this study is that mental imagery results in a cognitive bias which is manifested by an increase in the rate at which participants react to emotionally valenced stimuli. In other words, it is assumed that a cognitive bias will lead to faster processing of certain stimuli. However, many studies have shown that emotionally valenced stimuli are attended to preferentially, and therefore processed faster, especially when competing stimuli are not emotionally valenced (Calvo et al., 2003; Lang & Bradley, 2009).

A further key assumption which is made in this study, and which was briefly touched on in Section 1.5 of Chapter 1, is that processing resources are finite and therefore limited. As previously mentioned, this premise is based on the information processing paradigm, a theory which inherently assumes cognitive resources to be limited (Hertwig & Todd, 2003). According to this system, the two key limitations on cognitive processes are storage capacity and the capacity of information processing, and it is further hypothesised that these limitations present a burden which constricts cognitive potential. The terms cognitive resources and processing resources are used interchangeably in the context of this study, and are taken to refer to the means through which external stimuli are interpreted internally by a person. Thus, cognitive resources include processes such as item detection, attention, evaluation, and response selection all of which influence the rate at which the stimulus is responded to. When claiming that these resources are limited, it is assumed that the amount of information which a person is able to compute is inherently limited by the cognitive resources of that person. This in turn results in the assumption of sharing (Barrouillet & Camos, 2007). Thus, for example, attention is seen to be a limited resource which must be shared between the various stimuli (Barrouillet & Camos, 2007). Therefore, an increase in attention to one stimulus necessarily results in a decrease in attention to the other stimuli. Put differently, a benefit to one stimulus results in a cost to another. Thus, an increase in processing resources to emotionally valenced stimuli will result in processing costs to non-valenced stimuli, resulting in faster processing of the valenced stimuli, and normal or even impaired processing of the non-valenced stimuli. These assumptions are found in many models of cognitive psychology (Barrouillet & Camos, 2007), and are reasonable assumptions to make in the context of the current study.

As can be seen, all the assumptions made in this study are not only feasible, but are also either frequently found in many models currently informing contemporary psychological knowledge or have been supported by previous studies (Barrouillet & Camos, 2007). Thus, the use of these base assumptions in no way undermines the findings of this research.

2.7 Research questions addressed

The purpose of this section is to explicitly lay out the research questions being explored in the current study. There are two secondary questions and one primary question which will be addressed: the main aim of this study being to establish whether engaging in mental imagery affects reaction rate to emotionally valenced stimuli, whilst the secondary aims are to examine what effects age has on reaction rates, and to explore whether there are any gender-related effects on reaction rates to the various scenarios.

2.7.1 Research Question 1: Age-related differences

As was discussed in Section 2.1, the effects of ageing in several cognitive domains can be seen through a speed-accuracy trade-off in which older adults are slower but more accurate than younger adults (Starns & Ratcliff, 2010). However, it is unclear whether this same trade-off would be observed in reaction rates to emotionally valenced and non-valenced stimuli. Thus one of the secondary objectives of this study is to clarify this point with the research question being: Are there any significant age-related differences in reaction rates across the various conditions? The hypothesis underlying this aim is based on this speed-accuracy trade-off model, and proposes that older adults will have significantly slower response rates to the various types of stimuli when compared with younger adults.

2.7.2 Research Question 2: Gender-related differences

A further secondary aim of this study is to see whether there are any observable and significant differences in the reaction rates and accuracy between male and female participants. As was pointed out in Section 2.1, gender-related differences in terms the processing of emotional content have not been thoroughly researched. However, Lithari et al., (2010) do report that gender differences exist both in how men and women process emotions and in how they react to emotions. Thus a secondary aim of this study is to explore whether such differences can be found in the reaction rate to emotionally valenced stimuli, as this may contribute to our understanding of gender-related differences in emotional processing in general. The research question here would therefore be: Are there any significant gender-related differences in reaction time across the various conditions? The hypothesis in this section is non-directional, and merely states that there will be significant differences between male and female participants in their reaction rates to the various types of stimuli.

2.7.3 Research Question 3: Effect of mental imagery on reaction rates

The primary aim of this study is to explore the link between mental imagery and to examine whether mental imagery could influence the processing rate of stimuli. This will be done by examining how various mental imagery scenarios affect the rate at which emotionally valenced stimuli are reacted to. To this end, the research question being explored here is: Do positive, negative, and neutral mental imagery have an effect on reaction rates to positive, negative, and neutral stimuli? It is hypothesised that engaging in positive mental imagery would result in a person being quicker at responding to positive stimuli. Vice versa, negative mental imagery would bias a person to react to negative stimuli faster than to either positive or emotionally neutral stimuli.

More explicitly, the hypotheses underlying this primary aim propose that engaging in negative mental imagery will bias a person towards negative stimuli, and that this bias will be demonstrated by an increase in the speed at which participants responded to negative stimuli relative to positive or neutral stimuli. Similarly, it is further hypothesised that engaging in positive mental imagery will result in a bias towards positively valenced stimuli, which again will result in participants being faster to react to positive stimuli than to neutral or negative stimuli. In the control condition, the hypothesis maintains that neutral imagery will not bias response rates to any particular type of stimulus, resulting in similar response rates to all three types of stimuli.

Accordingly, in order to address the questions raised earlier and to fill in some of the gaps in previous research, this study attempts to experimentally induce a temporary bias toward both positive and negative situations, and to objectively measure the impact of such a bias on sensitivity to positive and negative stimuli respectively through the use of a specifically designed measure. The next chapter will focus on how the study was carried out.

CHAPTER 3
METHOD

The previous chapter explored the research contexts from which the questions of the current research were drawn. Chapter 2 also included an exploration of previous research and the weaknesses of some previous research methods. The current chapter specifies how the current study was conducted, with descriptions of the sample and the measurement instrument employed. Data analysis procedures are also described and justified.

3.1 Research design

The purpose of this study was to establish whether mental imagery could be used to create a cognitive bias which would result in changes in reaction rate to emotionally valenced stimuli. This study therefore used a quantitative approach as cognitive biases are not as readily observable from a more qualitative point of view, due to their often subconscious nature. Therefore, a computer program (described more fully in Section 3.3) was written to measure the reaction rates of the participants to emotionally valenced and neutral words under both a control condition and under two experimental conditions (please see Appendices 1 to 3 for a list of the stimuli used). Accordingly, there were two categorical variables. The first of these was mental imagery with three levels, namely positive mental imagery, negative mental imagery, and neutral mental imagery, whilst the dependent variable was reaction time. As reaction time is a continuous variable, this was measured on a ratio scale. In this case, reaction time was objectively measured in milliseconds through the use of a computer program. The computer program measured how long the participants took to respond to each of the stimuli in each of the conditions, and exported this data to a spreadsheet for later analysis. This reaction time was measured in the two experimental positive and negative mental imagery scenarios, and in the neutral mental imagery scenario, which acted as the control condition (please see Appendix 4 for the scenarios used). Each scenario was separately introduced, and participants were asked to respond to 15 emotionally valenced stimuli which were presented after each scenario. Of these 15 words, five were positively valenced, five were negatively valenced, and five were neutral; this stimulus valence was the second categorical variable, also having three levels, namely positive, negative, and neutral valence, thereby giving the study a factorial 3x3 design.

3.2 Sample selection

As this study aimed to achieve a normative understanding of how mental imagery influences reaction rates, care was taken to ensure that a wide range of participants was used so that the results of this study would be as generalizable as possible. To this end, participants were selected from different age groups and different social economic status groups in order to have as varied a population pool as possible. However, there were certain selection criteria which needed to be fulfilled before a person could be considered eligible to take part. As this study dealt with emotions, and as children may not have developed sufficient cues in response to emotionally valenced stimuli, only adults were asked to participate. In the case of this study, an adult was taken to be any person over the age of 18. Potential participants were also screened to ensure that no participants with psychological and/or cognitive disorders took part in the study, as this would have undermined the validity of the study. In other words, a disorder may have acted as a confounding variable by giving the participant an inherent bias which was not induced by any of the experimental conditions. In addition to this, people who have never used a computer before were also not included in the study, as computer literacy could also have been a confounding variable and could have affected the results. People who do not have a firm grasp of the English language were also not asked to participate, as delays caused by difficulties in understanding the meaning of a stimulus would have nullified the validity of that person's reaction rates. In the case of this study, English fluency was established via interaction between the researcher and the potential participant. Thus, the sampling frame from which the research group was drawn consisted of English speaking computer literate adults who have no history of mental, emotional, or neurological problems. Even with the presence of these selection criteria, the target population was large. Nevertheless, in order to facilitate the data collection procedure, a snowballing effect was utilised whereby existing participants were asked for a referral to other people who may have been interested in taking part in the study.

As this sample frame excludes a proportion of the general South African population, probability sampling and systematic sampling procedures were not applicable in this study. Furthermore, as the sample frame was not divided into sub-groups, stratified sampling procedures were also moot. Due to this, this study employed non-probability sampling; more specifically, a purposive sampling procedure was used. In other words, the participants used in this study were selected because their inherent features and characteristics were best suited to the purpose of the study. This purposive sampling procedure, whilst not as generalizable as random sampling procedures, is particularly relevant to experimental studies such as this one, as this ensures that the sample is archetypal and normative (Terre Blanche, Durrheim, & Painter, 2006). In other words, the sample ought to be highly representative of the larger population. Thus, the participants in this study were selected based on availability, willingness to take part in the study, and conformity to the selection criteria listed above.

3.3 Research instrument

As the hypotheses to be tested in this study required the use of mental imagery, the study used three scenarios with imagery instructions designed to make the participant actively become involved with the mental image (see Appendix 4 for the three scenarios used). Previous studies have found such imagery instructions to be successful in promoting participants to engage in mental imagery (Holmes et al., 2009). Each research participant was first asked to imagine a neutral situation which did not evoke negative or positive emotions. This prepared scenario was presented on the screen for the participant to read through in his or her own time, allowing him or her to fully imagine the scenario. Once the participant was ready, he or she was then presented with 15 single word stimuli, presented on the screen individually, to which the participant had to respond by categorising the stimulus word as “positive”, “negative”, or “neutral”. Reaction times to each stimulus were then recorded. The hypothesis underlying this first scenario was that as the imagery was neutral, there would be no bias towards either positive or negative stimuli. Any bias observed in this section would therefore have been caused by a pre-existing bias. Thus, this first section of the study acted as a control to ensure that there were no pre-existing biases which could influence the results, as well as acting as a base-line against which the reaction times in the experimental conditions could be compared. The participants were then asked to read through and imagine a positive situation which was described using positively charged words. After this, the reaction times of the participant toward a different selection of positive, negative, and neutral stimuli were measured. This time, the hypothesis was that positive mental imagery would bias the participant towards positive stimuli, resulting in shorter reaction times to positive stimuli relative to the negative and neutral stimuli. In the third section of the experiment, the participant was asked to read through and imagine a negative situation which was described using words which have negative connotations. This was followed by the presentation of a new set of neutral and valenced stimuli to which the participant was asked to respond. Both of the experimental conditions and the control condition had a very similar length to ensure that the amount of mental imagery engaged in in each of the conditions was approximately the same. Also, care was taken to ensure that none of the words used in the imagery conditions was repeated as a stimulus word and vice versa. It was hypothesised that the negative mental imagery would bias the participant to negative stimuli, and that the participant would therefore respond faster to negative stimuli than to positive or neutral ones. A vivid description of the various scenarios was used to encourage the participant to experience partial aspects of the emotions being conveyed, which thus promoted the participant to make inferences about how they would feel in such a situation (Niedenthal et al., 2009).

The stimuli used in this study were drawn from the Affective Norms for English Words (ANEW) list (Bradley & Lang, 2010). The ANEW list consists of a large number of common English words which have been examined to determine the normative emotional ratings of each word. Thus, each of the entries contains, amongst other things, information about the valence of the word, and about the amount of arousal generated by the word. Whilst this list is based on American norms, it is still applicable to the English-speaking South African population as only those participants fluent in English were selected for the study. The ANEW presents word valence on a scale of 1 to 9, with 1 being very negative and 9 being very positive. 45 words were selected in total, with 15 positive words, 15 negative words, and 15 neutral words. Negative words were defined as any word with a valence rating of less than 4.00 on the ANEW list, whilst positive words were deemed to be those words with a valence rating greater than 6.00, with neutral words being those words with a rating between 4.00 and 6.00. (See Appendices 1 to 3 for a list of words used, along with their valence and arousal scores.) The stimuli were selected from the "All Subjects" category, meaning that the arousal and valence scores were calculated based on data collected from both male and female participants. This was done to make the computer program usable and relevant for both male and female participants, thereby allowing for the collection of sufficient data for a comparison on reaction rate between the two genders. Had a computer program been specifically written for each gender, then differences in stimuli used would have resulted in difficulties in accurately drawing inferences about gender differences. Further to the selection of the stimuli, all words used in this study were unambiguous, with the boundaries said to be narrow (Starns & Ratcliff, 2010). Put another way, as decisions about the categorisation of the stimuli in this study were small, these decisions could be made quickly, despite the risk of decreased accuracy inherent in increased speed. This was important in ensuring that there would be no advantages of some words relative to others in terms of the processing power required, thereby ensuring that age-related differences could be contributed solely to age differences.

As this research design necessitated the recording of reaction times, a computer program was written to accurately time each participant's response. The programming language used was *C#*, due to its simple and general-purpose nature, and the compiler used was *Microsoft Visual Studio 2010 Professional*. All the stimuli words were compiled into a .CSV file, named *words.CSV*. Once the program loads, it reads this .CSV file into a two-dimensional array. The array had to be arranged as two dimensional as it stored two Strings in each index. The first String was for the stimulus being used, whilst the second String contained the correct categorisation of the stimulus, allowing the answer given by the participant to be compared to the answer contained in the second String. In order to time the response rate, the Stopwatch object was used. Thus, once the stimulus was displayed on the screen, the Stopwatch began timing, and this timing was immediately paused when the participant clicked on their chosen answer. The program then determined whether the answer was correct and exported the stimulus word, the selected category, the correct category, and the reaction time to a separate .CSV file. After this, the program randomly chose the next stimulus from the *words.CSV* file, upon which the Stopwatch reset and started timing the response again. This was repeated until all stimuli in the *words.CSV* file had been selected and timed.

From the point of view of the participant, the program first displayed the neutral mental imagery scenario, followed by 15 stimuli (five positive ones, five neutral ones, and five negative ones, presented in a random order). The program presented one stimulus at a time on the screen, and participants were asked to categorise the stimuli by clicking one of three buttons presented on the screen ("positive", "negative", or "neutral" buttons). Thus, the participant's reaction time was taken to be the amount of time, measured in milliseconds, which elapsed between the presentation of the stimuli on the screen and the time at which the participant pressed a button. The program automatically recorded the time taken, and exported this data to a spreadsheet so that the information obtained could be analysed further. Furthermore, although 15 words were presented after each scenario, with five of the 15 words being positively valenced, another five being negatively valenced, and the other five words being neutral, the order of these 15 words was random, thereby avoiding any confounding effects due to word order. Put another way, although the 15 words consisted of an equal distribution of the three types of stimuli, the exact stimuli selected from each type of stimuli varied with each run of the computer program. This ensured that the order in which the stimuli were presented had absolutely no influence on the reaction rates.

3.4 Data collection procedure

Data were collected from the sample population until 80 usable sets of data were gathered, with 40 sets from males, and 40 sets from females, thereby also providing ample data for the exploration of gender differences. This sample size was large enough to make inferences of generalizability, and is comparable to the sample sizes used in other CBM studies (Hoppitt et al., 2010). Simultaneously, this sample size was also large enough to ensure the validity and reliability of the research. A variety of data was collected from each participant, including demographic information and reaction rates. In other words, the computer program recorded the age and gender of each participant, as well as the reaction rates to valenced stimuli, measured in milliseconds. Additionally, the program also recorded the particular order of the stimuli with which each participant was presented, as well as whether the participant correctly categorised each stimulus as “positive”, “negative”, or “neutral”. This was done so that accuracy rates could also be examined. To ensure that the data collected were free from any interference, they were collected in quiet locations and at times convenient to the participants so as to avoid any distractors which may influence the results. Furthermore, all instructions were coded into the computer program to ensure that no instruction bias affected the results. Also, one half of the data sets were collected during morning sessions and the other half of the data sets were collected in afternoon sessions, both for the convenience of the participants, and to ensure that there would be no time-of-day effects on the reaction rates.

3.5 Validity and reliability considerations

In terms of the validity of this measurement procedure, response time was automatically measured, resulting in highly accurate results. Furthermore, the inclusion of three situations (namely the positive, negative, and neutral) ensured the internal validity of the study. As is stated by Terre Blanche et al. (2006), the internal validity of research can be considered to be strong if the results are not readily explainable by rival hypotheses, but are actually caused by the intervention itself. As the inclusion of a control eliminated the primary confounding variable of pre-existing biases, any observable biases were likely to be caused by the mental imagery, and thus the internal validity of this study is greatly strengthened. Furthermore, the external validity of this study was also relatively high as the sample was drawn from the educated, South African urban population, and is therefore representative of and generalizable to the similar populations of other developed countries. As this study relied on a computer program to time response rates, the findings are highly reliable. In other words, the results which this study yielded are reproducible both on an individual level, and on the level of the study itself (Terre Blanche et al., 2006). However, some secondary validity concerns may arise, which shall now be addressed.

As the validity of the measurement technique can be undermined if the emotional valence of stimuli is incorrect, care was taken to ensure that the positive, negative, and neutral stimuli used in the study were really experienced by the participants as being positive, negative, and neutral respectively. Great care was taken in choosing stimuli which were either extremely negative or extremely positive; in other words, stimuli which left no room for ambiguity. As mentioned before, this was done by selecting stimuli from the ANEW list based on the ratings of the valence of each word, thereby indicating that the American sample on which the list was based experienced the stimuli as either very negative or very positive. However, it must be borne in mind that these scores merely represent an average; it is possible that some people may have negative associations to positive stimuli or vice versa. For example, whilst "Christmas" is a positive stimulus for the general population, it would be perceived as negative for a person who lost loved ones over the Christmas period. This interaction between the valence of the stimulus and a person's own experiences with that stimulus presented a confounding variable. This confounding variable is, however, an exception to the norm, and therefore could not have been controlled for unless the relationships between the stimuli used and each participant's experiences were to have been explored. However, other research studies using words as stimuli has done this, and has tailored the list of words used to each person. This was done by asking the participant to rate the valence of a long list of words prior to the retraining, and then selecting the words rated most strongly in the actual training (Bar-Haim, 2010). As such research was conducted on a clinical population, the sample sizes were small enough to make such efforts practicable. However, this technique was clearly not feasible for this study due to the much larger sample size. Additionally, as the sample in this study was drawn from a non-clinical population, the participants would most likely not have had a unique interpretation of a general stimulus. Furthermore, due to the size of the sample, an in-depth interview to establish idiosyncratic valence would have been too time-consuming, and an exploration of stimulus-experience inter-relationships would also have been beyond the scope of the present study. However, because of this possible confounding variable, the content validity of the measure may not have been as high as possible.

The content validity was, however, increased by the selection of biologically valenced stimuli, regardless of whether the stimulus was concrete or abstract. Thus, the positive and negative stimuli used were of a biological nature; as protecting one's wellbeing is instinctual, it can be assumed that a biologically threatening or rewarding stimulus will mean the same to almost everyone in a non-clinical population. According to Sakaki et al. (2012), emotionally valenced stimuli may be either of a biological or social nature. For example, the word "bomb" is a biological stimulus as it is directly relevant to a person's survival, whilst "Christmas" receives its valence from a social context. However, how these two types of stimuli affect cognitive processes may not be the same: biological stimuli are processed automatically, whilst socially relevant stimuli undergo more elaborative processing. In order to avoid differences in reaction rate being caused by differences in cognitive processing, all stimuli were chosen for their biological valence. Furthermore, biologically valenced stimuli have a clear and direct association with a particular outcome (Sakaki et al., 2012), and are therefore less ambiguous than socially valenced stimuli, which are often context dependent. Moreover, recent studies indicate that biologically valenced stimuli are processed equally fast, regardless of whether the stimulus is positive or negative, or whether or not the stimulus is expressed as an abstract concept (Sakaki et al., 2012). This is important, as it ensures that there was no bias towards the faster processing of negative or positive stimuli.

A further threat to the validity of the research was the computer literacy of participants. In other words, some potential participants may not have known how to properly use a computer, which would have affected their reaction rate to the stimuli. To avoid this, in addition to having drawn the sample from a computer literate population, the computer program also incorporated a few practice stimuli. This was done to ensure that all participants understood the exact requirements of the computer program and how the program functions before any reaction rate measurements took place. Thus, the effect of computer literacy on reaction rate was minimised, and the measurement validity was increased.

Another factor which could have influenced the reaction rates was how the “positive”, “negative”, and “neutral” buttons were arranged. For example, if they had been placed too far apart, valuable time would have been lost whilst moving the mouse cursor to the relevant button. If the buttons had been placed in a list format, then the button at the bottom would have taken longer to reach than the button at the top, thereby increasing the time it would have taken to press the bottom button. Therefore, the buttons were placed close together horizontally with the neutral “neutral” button in the middle of the “positive” and “negative” buttons, thereby equalising the distance which the mouse cursor had to move between the positive and negative buttons, ensuring that neither was biased in terms of how far the participant needed to move the mouse cursor.

To sum up these reliability and validity considerations, the main uncontrolled for threat to validity is the effect of atypical experiences of a particular stimulus leading to that stimulus being attributed with a different subjective valence when compared to the general population. However, such an effect is unlikely given the stimuli chosen and the population from which the sample was drawn. All other threats to the validity and reliability of the measure have been controlled for in one way or another. Consequently, this measure can be said to have reasonably high validity and high reliability, thereby justifying the use of this measure to address the research question.

3.6 Data analysis procedure

Once the raw data had been collected and collated, a series of descriptive and inferential statistical procedures were conducted on the raw data. This was done in order to identify any trends in the data, as well as to establish the strength of those trends. To begin with, the descriptive statistics used will be examined, before going on to look at the inferential statistical techniques, and the reasons for their use. This statistical analysis was done using *Microsoft Excel 2010 Professional,* with the Analysis ToolPak add-in activated.

3.6.1 Descriptive statistics

First of all, the average valence and arousal scores of the positive, negative, and neutral stimuli used in the study were calculated, as this was vital in verifying that the stimuli used in the computer program were actually relevant in gathering data to address the research question. Also central to the topic of the relevancy of the stimuli was the number of incorrect categorisations made. For this, the norms drawn from the ANEW list were seen as the "correct" evaluation of the valence. Therefore, if participants categorised a stimulus into any category other than the "correct" categorisation according to the ANEW list, this categorisation was considered to be "incorrect". For example, according to the ANEW list, "paralysis" has a valence of 1.98 (Bradley & Lang, 2010). As this valence is extremely low, it designates the valence of the stimulus as being negative. Thus, if a participant were to categorise "paralysis" as being positive or neutral, then this categorisation would deviate from the category designated to the stimulus based on the ANEW valences, and this would therefore be considered to be an "incorrect" categorisation. This distinction between correct and incorrect was made so that it would not only be possible to obtain data on the accuracy of the response rates in the current study, but also so that inferences could be made regarding the degree to which there was intercultural agreement about the valence of the stimuli involved. Put another way, if there were only a small number of so-called incorrect categorisations, then that would be an indication that the South African sample tested in the current study awarded the stimuli with similar valence values as the American samples used to create the norms in the ANEW list. This in turn would demonstrate a high degree of intercultural agreement on the valence of the stimuli.

Having looked at the descriptive statistics of the stimuli used in this study, the descriptive statistics pertaining to the demographics of the participants were reported. This included calculating the age range, mean age, the standard deviation of the ages of the participants, as well as the distribution of male and female participants over the various ages. These were calculated in order to gain a better understanding of the sample population. Furthermore, the ages of the participants were divided into six distinct age groups in order to facilitate later analyses of how reaction rates changed as a function of age.

Following on from these statistics, the average reaction rates of the participants to the various stimuli were examined. The average reaction rates to each of the stimuli and under each of the three different types of scenarios were presented. Subsequently, the descriptive statistics pertaining to the age-related reaction rates were examined. More precisely, the average reaction rates for each age group were collated and divided up into the three separate scenarios, with each scenario containing the average reaction rates to each of the three types of stimuli for each age group. Graphic representations of results were also created where relevant to aid in the visual representation of interesting trends in the data. The Pearson's correlation coefficients were also calculated for each of the scenarios. This was done in order to verify the strength of the relationship between age and average reaction rate in each of the scenarios. Also pertinent to the effects of age on reaction rate was the number of incorrect categorisations made per age group. The descriptive statistics for this were also provided, and focused on the average age per age group, the number of participants per age group, and the average number of incorrect categorisations per age group. The Pearson's correlation coefficient value was also calculated in order to establish the strength of the relationship between age and the number of incorrect categorisations made. Pearson's correlation coefficients were used in these instances as they provided information about the strength of the relationship between two variables. The resulting r-values can range from 1 to -1, with values closer to 1 indicating a strong positive correlation, and values closer to -1 signifying that the variables have a strong negative correlation. Conversely, values of around 0 indicate that there is no correlation between the two variables (Terre Blanche et al., 2006). Practical significance was also taken into account to ensure that any significant results were indeed substantial.

Finally, the descriptive statistics pertinent to the gender differences were explored. As one of the secondary aims of this study was to examine the differences in reaction rate between male and female participants, it was essential to first inspect the demographics of the two genders before going on to calculate the inferential statistics relevant to gender differences. This last part of the descriptive statistics section contained information about the age range, average age, standard deviation of the age data, and the total and average number of incorrect categorisations made by the two genders. In addition to this, reaction rate data were also correlated by gender, resulting in the average reaction rates for males versus females for all three types of stimuli and under all three types of mental imagery conditions. This was done in order to facilitate an elementary overview of the gender differences in average reaction rate before the statistic validity of these results was calculated using inferential statistical procedures.

3.6.2 Inferential statistics

In addition to the descriptive statistics, inferential statistics were also used to test the hypotheses which were being studied in the current research in order to determine that the observed trends were significant. Two types of inferential statistics were utilised. The first of these was a factorial ANOVA used to test the main hypotheses underlying this research (as laid out in Section 2.7.3). The second statistical technique on the other hand, was a t-test used to ensure that any gender differences observed in the descriptive section of the results were significant, and therefore of relevance to the current study (see the hypothesis set out in Section 2.7.2). Although this could have been analysed using a three-way ANOVA looking at the factors of gender, stimulus valence, and imagery type, this statistical function is not supported by the software used for data analysis (*Microsoft Excel 2010 Professional*), thereby necessitating the use of multiple t-tests.

As there were three levels of the two categorical variables, a factorial ANOVA was used in the interpretation of the raw data. This was done in order to determine whether there were any significant differences in reaction times under the various imagery and valence conditions, or whether the observed results were obtained by chance. A factorial ANOVA was used as this allowed for the analysis of both main effects and interaction effects. In other words, a factorial ANOVA was used as it not only indicated the degree to which the conditions affected reaction rates, as well as to what extent the valence of the stimuli had an effect on the reaction rates, but this type of ANOVA was also able to provide information on the interaction between mental imagery and the valence of the stimuli. ANOVAs are a useful statistical analysis method in studies such as this one as they ensure that intergroup variation of means is significant when compared to random sampling variation (Terre Blanche et al., 2006); in other words, ANOVAs safeguard that the results obtained are not observed by chance, but are the observed indicator of an effect. Thus, this method of analysis was suitable for the data obtained, and was also sufficient for addressing the research question which was explored in the current study. As the study called for only a single ANOVA comparison, the Type 1 error (which is an increased likelihood of the false rejection of the correct null hypothesis) was not likely. In addition to this, as the sample size of this study was fairly large, there was no increase in the risk of a Type 2 error (meaning that an incorrect null hypothesis has less chance of being rejected). As a result of these power considerations, a p-value of 0.05 was considered to be an acceptable level of significance for this study. Indeed, an A priori power analysis done using *G*Power* (version 3.1.9.2) using an alpha error probability rate of 0.05 and an effect size of 0.5 (considered to be large) yielded an actual power value of 0.96 and a required total sample size of 39, thereby indicating that the power considerations of this design were satisfactory. This ANOVA was therefore used to show whether the reaction rate to valenced stimuli was significantly affected by mental imagery, or whether the observed results could be explained by probability and observed through chance. In order to determine whether any statistically significant results found in the ANOVA analysis were truly significant, a Fisher's Least Significant Difference post hoc test was performed to increase the confidence in the obtained results by minimising the likelihood of false positives.

In addition to the factorial ANOVA, separate two-sample t-tests were performed on the mean reaction rates for men versus women for each of the three conditions to discover whether there were any gender differences in sensitivity to mental imagery. As mentioned before, it was not possible to do a three-way ANOVA in *Microsoft Excel*, thereby necessitating the use of multiple t-tests. Accordingly, the raw data was divided into reaction rates to neutral stimuli, reaction rates to positive stimuli, and reaction rates to negative stimuli in each of the three conditions for male participants versus the reaction rates for female participants. In all of the conditions, the hypothesis being tested was that there was a gender-related difference in reaction rates (see hypothesis outlined in Section 2.7.2). Thus, the null hypothesis for each of the conditions stated that there would be no gender-related differences in reaction rates. A p-value of 0.05 was set as the significance level for these three t-tests, as such a p-value is low enough to ensure that results are significant, but not so low that there is a risk of incorrectly accepting the null hypothesis. In addition, as each t-test was performed on a separate set of data, there was no increase in the risk of Type 1 error. The use of these nine two-sample t-tests served to illustrate whether there were any real and significant gender differences in reaction rates. Due to the use of multiple comparisons, there is an increase in the risk of cumulative error, thereby indicating that a Bonferroni correction ought to be used. Although the power considerations of this study were sufficient to avoid using a Bonferroni correction, this correction was nevertheless applied in order to increase the strength of the results. Whilst this did not directly contribute to the primary research question, these results were important in addressing one of the secondary aims of this study, namely to further the understanding of gender differences, which in turn may help to explain why and how gender differences in various emotional disorders exist.

3.7 Summary

To summarise, the main aim of the current research was to establish whether mental imagery could be used to create a cognitive bias which results in the faster reaction rate to emotionally valenced stimuli. To this end, a computer program was designed to first measure reaction rates to positive, negative, and neutral stimuli under a control condition which used neutral imagery. This was done in order to establish a base-line of reaction rates as well as to determine whether any of the participants had any pre-existing cognitive biases. After this control condition, the program then went on to measure the reaction rates of the participants to positive, negative, and neutral stimuli under two experimental conditions, namely after the use of positive mental imagery, and after engaging in negative mental imagery. The raw data in the form of response rates measured in milliseconds were then subjected to various descriptive and inferential statistical procedures in order to extrapolate relevant results. These results will now be presented in the following chapter.

CHAPTER 4
RESULTS

As mentioned in the previous chapter, various statistical procedures were performed on the raw data obtained from the computer program. The methods of analysis which were used, why these were used, and the results they yielded shall be considered in this chapter. The results are presented in different sections: first are the descriptive statistics, as these are useful in obtaining an overview of the data, thereby providing an impression of any trends in the data. Following the section containing the descriptive statistics are the inferential statistics, which were used to test the hypotheses underlying this study, and to point out the significance of the results obtained.

4.1 Descriptive statistics

This section of the results shall first focus on examining the stimuli used in this study as well as how many incorrect categorisations were made, followed by an inspection of the demographics of the participants. Once this has been done, the average reaction rates will be reported. Whilst these results contribute to an overall picture of the trends in the data, it is also necessary to look at more specific questions, such as how these reaction rates interact with factors such as age and gender. Thus, the results pertaining to age and gender-related trends constitute the final portion of this section.

4.1.1 Stimuli applicability

Before examining the results obtained from the computer program, it is important to first consider the actual stimuli used in the data collection procedure. After all, had the program contained poorly suited or irrelevant stimuli, then any results obtained from such stimuli would be equally unsuitable for addressing the research question. In other words, it was necessary to examine the applicability of the stimuli used in the study. This was done by examining the valence and arousal scores of the stimuli to ensure that these stimuli were suited to the various stimuli categories. Table 4.1 shows the average valence and arousal scores for each of the three types of stimuli used: positive, negative, and neutral.

	Average Valence Score	Average Arousal Score
Positive Stimuli	8.30	6.36
Negative Stimuli	1.71	5.93
Neutral Stimuli	5.01	3.63

Table 4.1: ANEW Average valence and arousal scores of the stimuli used

As mentioned in Chapter 3, the stimuli used in the current study were drawn from the ANEW list of frequently used English words, as this allowed the valence and the arousal of the words to be taken into account. Arousal values were expressed on a scale, with 1 being minimally arousing and 9 being extremely arousing. Valence scores were expressed on a similar scale, with 1 being very negatively valenced, 9 being very positively valenced, and scores around 5 being seen as neutral, with both the valence and the arousal scores being obtained from the ANEW list (Bradley & Lang, 2010). As can be seen from Table 4.1, the average valence of negative words was extremely low, receiving an average score of 1.71 out of a possible 9, indicating that these stimuli had a very negative valence. The average arousal for the negative stimuli was 5.93, representing a moderately high amount of arousal. The positive stimuli on the other hand had a similar albeit slightly higher arousal, with an average arousal score of 6.36. The valence of the positive stimuli was very high, with an average rating of 8.30 out of a possible 9, signifying that the positive stimuli had a highly positive valence. Conversely, the neutral stimuli only had an average valence score of 5.01. As valence was rated on a scale from 1 to 9, a score of 5 represents the exact middle of the continuum, meaning that these stimuli are neither positive nor negative, but wholly neutral. The average arousal of these neutral stimuli was low, having an average score of 3.63, indicating that these stimuli had a far lower ability to excite and capture participants' attention.

What is interesting to note is that both positive and negative stimuli have an average valence score which is approximately 0.70 away from the two extremes of the continuum. In other words, as the continuum is rated on a scale from 1 to 9, 1 represents the negative extreme, whilst a score of 9 represents the positive extreme. The average negative stimuli rating was situated 0.71 from the negative extreme of the continuum, with a rating of 1.71. Equally, the average positive stimuli's rating fell at 8.30, exactly 0.70 away from the positive extreme of the valence continuum. From this, it can be concluded that the valence of the positive and negative stimuli was equivalent, albeit situated on opposite sides of the continuum. The arousal and valence scores for each of the three types of stimuli could therefore be considered appropriate for addressing the research question, thereby ensuring that any results obtained through the use of these stimuli were relevant to the research question under examination.

Having established that the stimuli used in the study were indeed applicable and relevant to the study, it is now important to consider other descriptive statistics pertinent to the stimuli. As the valence and arousal scores of the ANEW list were calculated using an American sample, it is also vital to consider whether these scores are equally applicable to a South African population. However, as the participants in this study were not directly asked to rate the valence and arousal of the stimuli included in the study, it was necessary to indirectly infer whether the South African sample deviated from the American norm by examining the degree to which the two samples agreed on the valence of the stimuli. In other words, if the South African sample did not diverge from the American sample, then the South African sample would have categorised all negatively valenced ANEW words as being negative, all positive ANEW words as positive, and all neutral ANEW words as neutral. Thus, a comparison of the accuracy of the South African sample based on the American standards contained in the ANEW list was used as an indication of the homogeneity of the two different samples. For the sake of this study, the valence category listed in the ANEW list was seen as the "correct" category, and any divergence from this was seen as an "incorrect" categorisation, despite the fact that cross-cultural variations in the understanding of a stimulus cannot be deemed as correct or incorrect. Figures 4.1 through to 4.3 therefore illustrate the number of discrepancies per condition for each of the three types of stimuli.

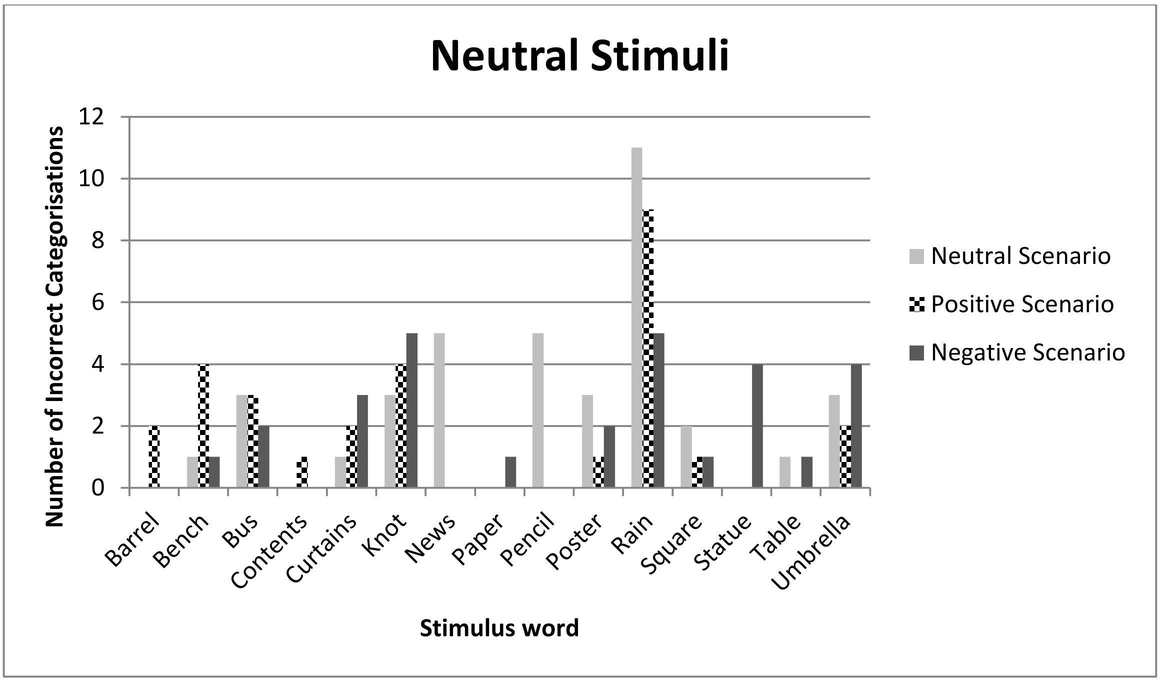

Figure 4.1: Number of incorrect categorisations of neutral stimuli

Figure 4.1 illustrates the number of discrepancies between how the participants in this study categorised the neutral stimuli and how the stimuli ought to have been categorised according to the norms presented in the ANEW list, as well as under which mental imagery condition or scenario this categorical discrepancy occurred. In other words, the performance of the South African sample on the categorisation of neutral words in each of the three conditions in the experiment was compared to the valence allocated to the stimulus in the ANEW list. As each stimulus was presented once to each participant, and as there were 80 participants, each stimulus was therefore repeated a total of 80 times in this study, resulting in a possible total of 80 incorrect categorisations. As the order in which the stimuli were presented in the program was randomised, each word had the possibility of occurring after the neutral imagery scenario, after the positive mental imagery scenario, or after the negative mental imagery scenario. The results in the above graph indicate how often each neutral stimulus was incorrectly categorised, as well as after which scenario the incorrect categorisation was made. Thus, as can be seen in Figure 4.1, the stimulus words “contents” and “paper” were each only incorrectly categorised once, after the positive mental imagery scenario and the negative mental imagery scenario respectively. “Rain”, on the other hand, was incorrectly categorised a total of 25 times: 11 times when it occurred after the neutral scenario, nine times after the positive scenario, and only five times after the negative scenario. What is interesting to note is that each neutral stimulus was incorrectly categorised at least once. In other words, there was no instance in which the categories allocated by the South African sample coincided completely with the valence scores on the ANEW list obtained from an American sample. In total, neutral stimuli were incorrectly categorised as either being positive or negative a total of 96 times. Of these 96 incorrect categorisations, 38 instances occurred after the neutral scenario, and the remaining 58 instances were evenly distributed between the positive and the negative mental imagery scenarios, with each scenario being followed by 29 incorrect categorisations.

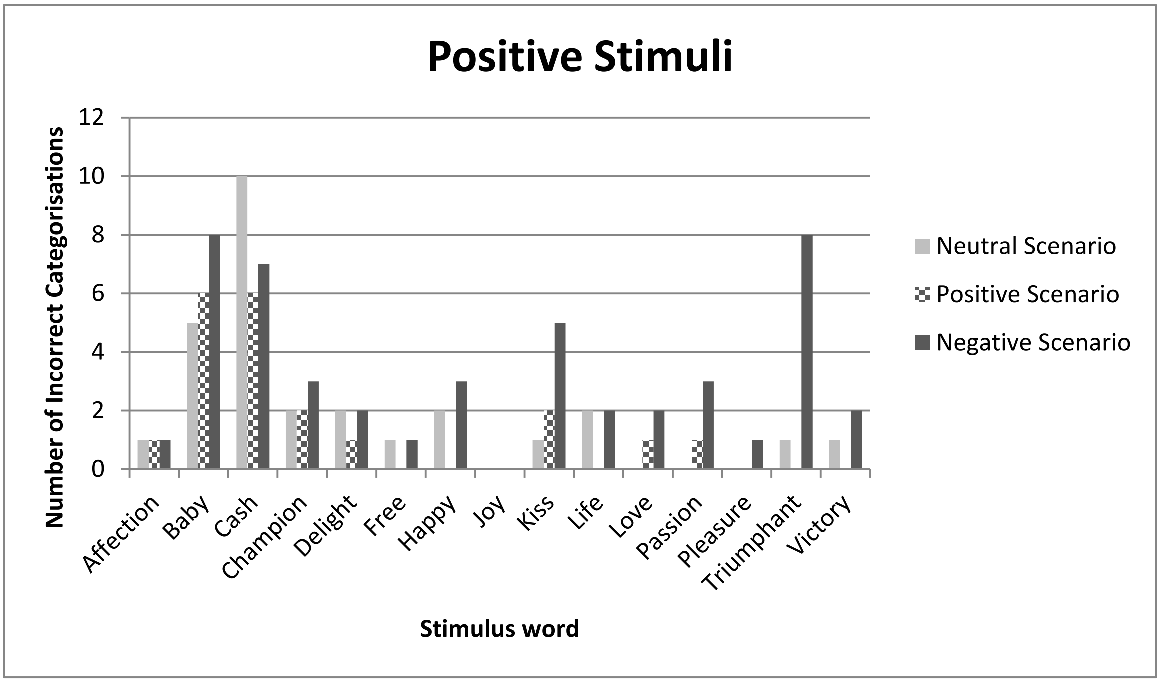

Figure 4.2: Number of incorrect categorisations of positive stimuli

The total number of incorrect categorisations of positive stimuli was also 96, the same as for neutral stimuli. As can be seen in the above graph, the only stimulus which was correctly categorised as being positive in all instances was “joy”. The most incorrectly categorised stimulus on the other hand, was “cash”, which was incorrectly categorised a total of 23 times: ten times following the neutral imagery scenario, six times after the positive mental imagery, and seven times after participants read the negative scenario. Overall, participants incorrectly categorised positive stimuli as either being neutral or negative 28 times after the neutral imagery condition and 20 times after the positive mental imagery condition. However, once participants had read the negative mental imagery scenario, the number of incorrect categorisations under this condition rose to 48. In other words, after the negative mental imagery condition, participants made as many incorrect categorisations as in the previous two scenarios combined.

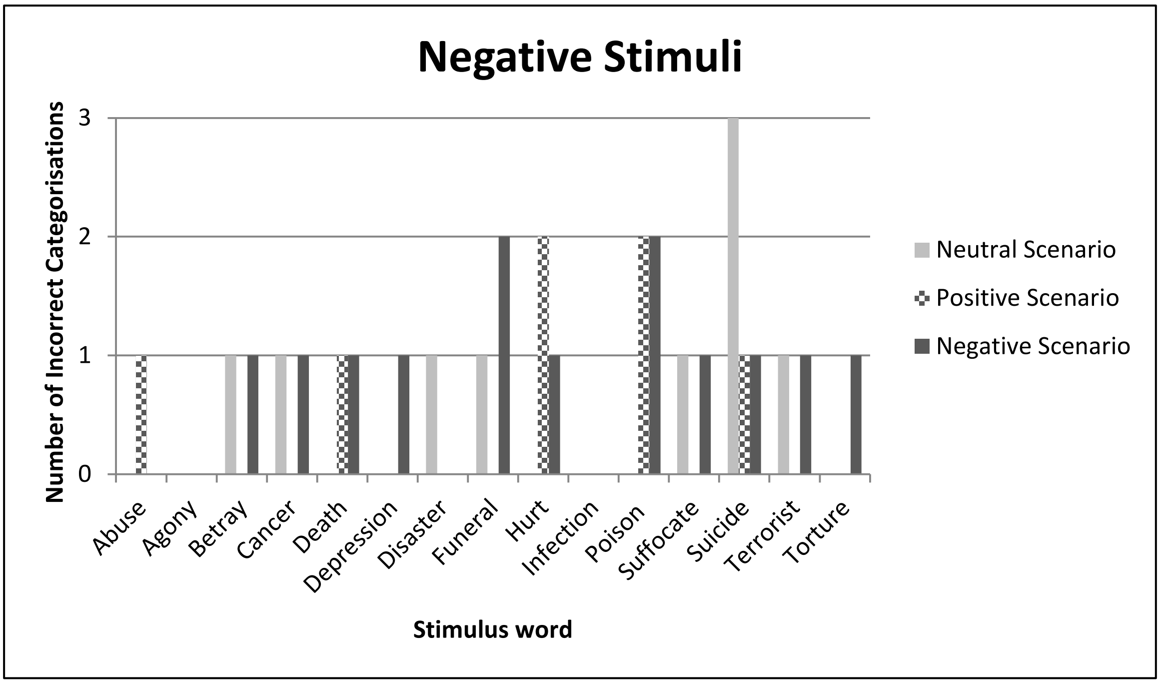

Figure 4.3: Number of incorrect categorisations of negative stimuli

As can be seen in Figure 4.3, there were far fewer incorrect categorisations of negative stimuli. In total, only 29 of such incorrect categorisations occurred, as compared to the 96 incorrect categorisations for each of the positive and neutral stimuli. Furthermore, both "agony" and "infection" were allocated the correct category in all 80 instances in which these two stimuli occurred. The most frequently incorrectly categorised negative stimulus was "suicide", with three incorrect categorisations in the neutral scenario, and one incorrect categorisation in each of the positive and the negative scenarios.

To summarise the results concerning the stimuli used in this study according to the data contained in the ANEW list, the stimuli used in this study were relevant to the question under examination. However, the statistics for the accuracy of the categorisation of the stimuli suggested that there was a degree of discrepancy between American norms and the valence allocated to the same stimuli by a South African sample.

4.1.2 Participant demographics

Having examined the pertinence of the stimuli used not only to this study, but also to a South African sample, it is time to analyse the statistics relevant to the sample used in this study.

An overall total of 81 participants completed the computer program. However, one set of data was not included in the analysis due to a response set bias which would have decreased the validity of the responses. Thus, a total of 80 sets of data were used, with 40 participants being male and 40 participants being female. The demographics of the sample used in this study are presented in Table 4.2.

	Ages 18-19	**Ages 20-29**	**Ages 30-39**	**Ages 40-49**	**Ages 50-59**	**Ages 60-69**	**Total**
n	3	47	14	12	1	3	80
n Female	1	23	9	6	0	1	40
n Male	2	24	5	6	1	2	40
Average age	18	25	33	44	52	63	30.5

Table 4.2: Demographic data of participants

As can be seen from Table 4.2, there was a total of 80 participants in the current study. They were evenly distributed between the two genders, with a total of 40 female participants and a total of 40 male participants. As the majority of the participants were clustered in the lower age groups, the age distribution was positively skewed. This positive skewing in age distribution was also observed in the distribution of the genders, with greater numbers of males and females being clustered in the lower age groups.

The age of the participants ranged from 18 to 64 years, with a mean age of 30.5, and a standard deviation of 10.4. In order to analyse the data for age-related effects, the participants were divided into six age groups, namely from 18 to 19, 20 to 29, 30 to 39, 40 to 49, 50 to 59, and 60 to 69. As can be seen in Table 4.2, each age group contained a similar number of male and female participants, with the exception of ages 30 to 39, which contained almost twice as many females as it did males. The other exception is the 50 to 59 age group, which contained a single male participant, and no female participants. What is also interesting to note is that, with the exception of the first two age groups, the average age of each age group was less than the median of each age group, thereby indicating that, on average, participants were clustered in the lower end of each age group, meaning that the distances between the average age per age group was fairly equal.

Having established that the stimuli used in this study were relevant to the study, and having examined the demographics of the participants of this study, it is time to look at the average reaction rates with which the participants responded to the various types of stimuli.

4.1.3 Average reaction rates

Table 4.3 presents the average reaction rates which were obtained by the participants in the control condition as well as in the two experimental conditions. These results were obtained by calculating the averages from all the relevant raw data using the appropriate Excel function. As was described in Chapter 3, *Microsoft Visual Studio 2010 Professional* was used to compile the program through which the reaction rates were obtained. Thus the confidence in the accuracy of the reaction rates, and therefore of the averages presented below, is high.

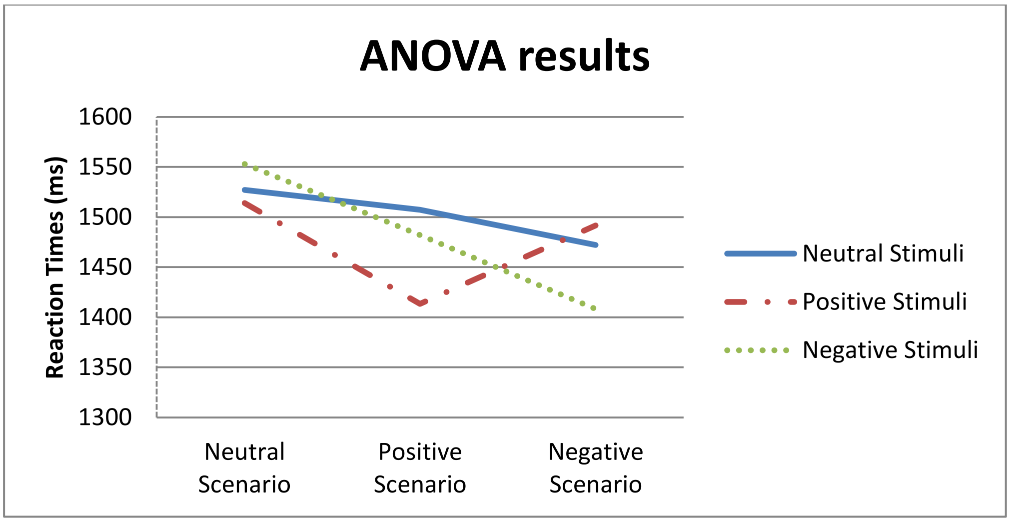

Figure 4.4: ANOVA of reaction rates in each condition in milliseconds

As can be seen in Figure 4.4, reaction rates in the control condition, or neutral mental imagery condition, are all fairly similar, with participants being fastest at recognising positively valenced stimuli, with an average rate of 1514ms. The response rate to neutral stimuli was marginally slower, with participants taking an average of 13ms longer to respond to neutral stimuli as compared to positive stimuli. In the neutral scenario, participants took longest to respond to the negatively valenced stimuli, with the average reaction rate in this case being 1553ms, resulting in an overall difference of 39ms between the fastest average reaction rate (positively valenced stimuli) and the slowest average reaction rate (negatively valenced stimuli). These findings appeared to be consistent with the hypothesis underlying this condition, namely that response rates to positive, negative, and neutral stimuli would not differ greatly (see Section 2.7.3 for hypothesis formulation). However, as these statistics were purely descriptive, the significance of this trend was not calculated. Therefore, rather than being taken as conclusive support for the hypothesis, the claim made here was that these descriptive results were consistent with those expected on the basis of the hypothesis, but that inferential analysis would be necessary in order for the support of the hypothesis to be clear.

After participants were exposed to positive mental imagery in the first experimental condition, average reaction rates were different from those in the control condition. Average response rates for neutral stimuli constituted the slowest response rates in this condition, with an average rate of 1507ms. This was similar to those found in the control condition, being only 20ms faster than the average reaction rate to neutral stimuli in the neutral scenario. The average reaction rate of participants toward positively valenced stimuli was the fastest, with an average of only 1413ms. In other words, in this experimental condition, participants on average were able to respond to positive stimuli 94ms faster than to neutral stimuli. Negatively valenced stimuli, on the other hand, were responded to at an average of 1482ms following the positive mental imagery condition. This average was 69ms slower than the average response rate to positively valenced stimuli. The hypotheses being tested in this condition stated that engaging in positive mental imagery would not affect the reaction rate to neutral stimuli, but would result in faster response rates to positively valenced stimuli as well as slower response rates to negatively valenced stimuli (see Section 2.7.3). The results presented in Figure 4.4 appeared to be consistent with these hypotheses. However, although these results seem to show conformity with the hypotheses, further inferential statistical analysis was necessary before this could be seen as unequivocal support of the hypotheses.

The second experimental condition exposed participants to negative mental imagery before measuring their response rates to neutral, positively valenced, and negatively valenced stimuli. In this condition, the slowest average response rate was to positively valenced stimuli, with an average response rate of 1492ms. This was 20ms slower than the average reaction rate to neutral stimuli, which was 1472ms. Participants on average responded much faster to negatively valenced stimuli, with the average reaction rate in this case being

1408ms. The hypotheses underlying this experimental condition were that engaging in negative mental imagery would not affect reaction rates to neutral stimuli, but would lead to a faster response to negatively valenced stimuli and a slower response to positively valenced stimuli (see Section 2.7.3). The average reaction rates in this case indicated that response rates to positively and negatively valenced stimuli were as expected. However, the results also showed that negative mental imagery did seem to affect response rates to neutral stimuli as well, a trend which was not hypothesised.

Figure 4.4 clearly shows that the overall fastest average reaction rate was the reaction rate of participants to negatively valenced stimuli after having been exposed to negative mental imagery, with an average reaction time of 1408ms. Conversely, the slowest overall reaction time occurred when participants were responding to negative mental imagery in the neutral or control scenario, with the average reaction rate being 1553ms.

4.1.4 Age-related reaction rates

One of the secondary aims of this study was also to examine whether age has any effect on the reaction rate to emotionally valenced stimuli (see hypothesis in Section 2.7.1). Figures 4.5 through to 4.7 illustrate the differences in average reaction rate between the various age groups under the neutral imagery condition, the positive mental imagery condition, and the negative mental imagery condition respectively. (See Appendix 5 for numerical values)

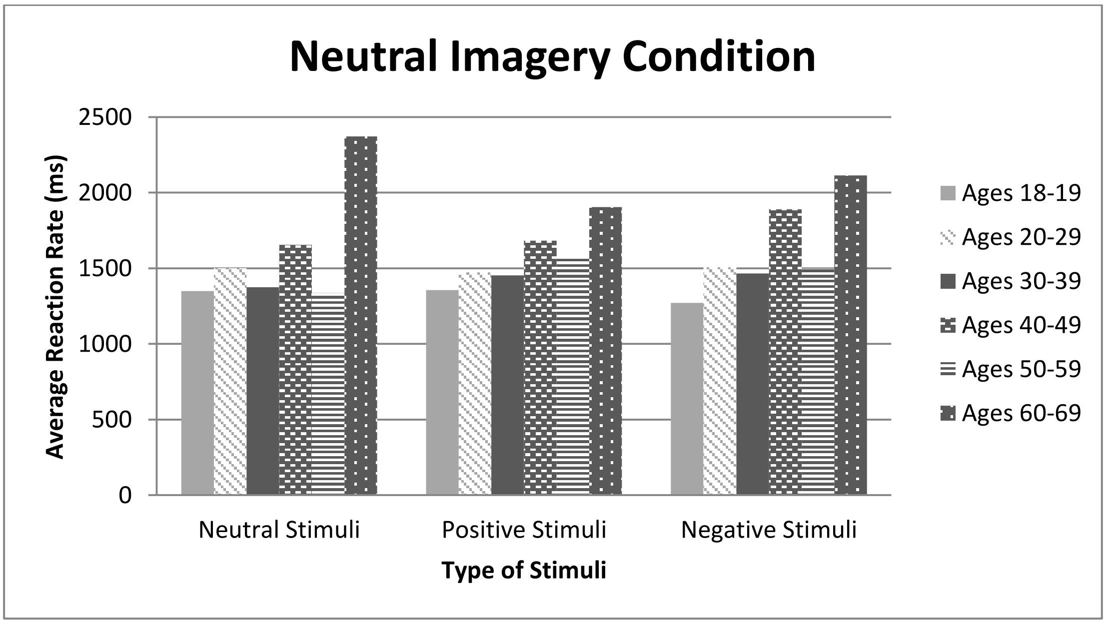

Figure 4.5: Age-related differences in reaction rate after neutral mental imagery

Figure 4.5 illustrates the different average reaction times obtained by each age group in the neutral imagery condition. As can be seen, reaction rate was fastest for the 18 to19 year old reacting to negative stimuli, with an average rate of 1272ms, with the slowest reaction rate of 2372ms being for the 60 to 69 age group reacting to neutral stimuli. However, the overall trend suggests that, with a few exceptions, the reaction rate of the participants increased as the age of the participants increased, indicating a positive correlation between age and the reaction rate of participants in response to neutral mental imagery. This trend was seen in response to neutral stimuli, and positively and negatively valenced stimuli, with the trend being most uniform in response to positive stimuli. A Pearson's correlation coefficient investigating the interaction between the average age per age group and the average reaction time per age group to all stimuli in the neutral imagery condition resulted in an r=.799. As this coefficient ranges from 1 to -1, the closer the value is to either 1 or -1, the stronger the correlation between the two factors. Thus, a value of r=.799 indicates that there is a strong positive correlation between age and reaction rate in the neutral imagery condition. In other words, the older the participants were, the longer they took to respond to the stimuli in the neutral imagery condition. The coefficient of determination (r^2) was also calculated in order to determine how much of the variance in the first variable is explainable by the second variable, and this yielded a value of r^2=.638, indicating that a large portion of the variation found in the neutral imagery condition is as a result of age differences.

Such a strong trend was, however, not present after the participants had engaged in positive mental imagery. Figure 4.6characterises the average reaction rates of the various age groups to neutral, positive, and negative stimuli after the participants engaged in positive mental imagery.

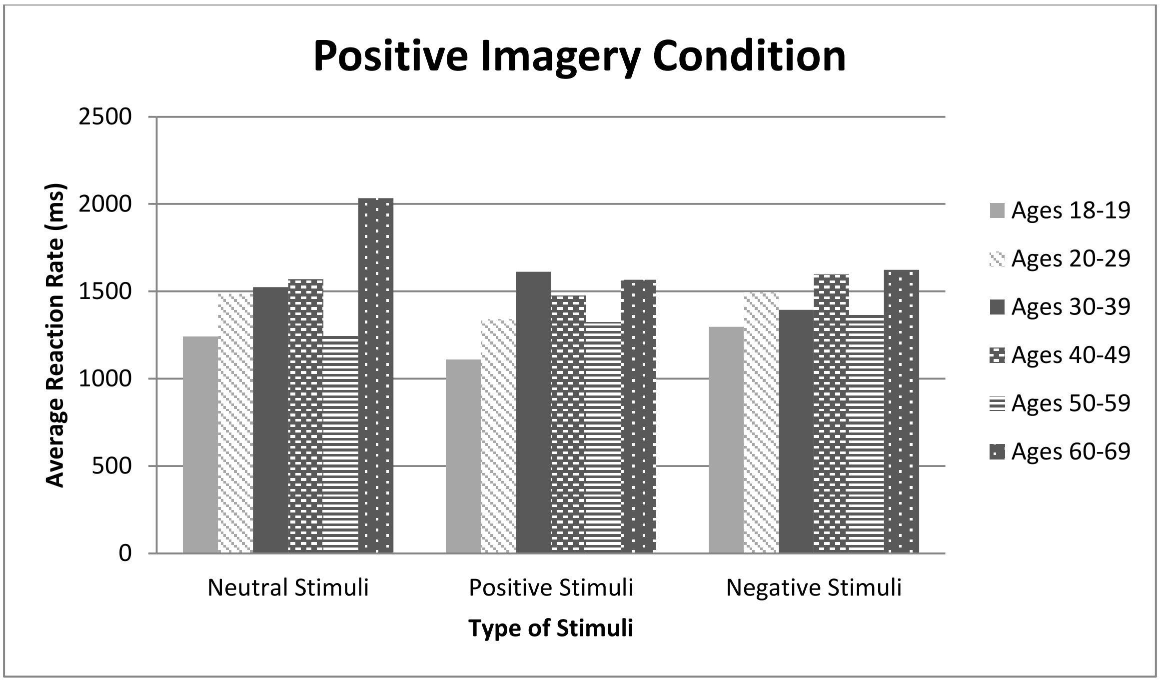

Figure 4.6: Age-related differences in reaction rate after positive mental imagery

After participants engaged in positive mental imagery, the fastest average response rate of 1110ms was obtained by the 18 to 19 age group, and the slowest average response was 2034ms, scored by the 60 to 69 year olds, replicating the findings from the neutral imagery condition. However, in this case, the fastest reaction rate was in response to positive stimuli, unlike in the neutral scenario, where the fastest average reaction rate was in response to negative stimuli. On the other hand, in both the positive imagery scenario and in the neutral imagery scenario, the overall slowest average response rate was scored by the 60 to 69 age group in response to neutral stimuli. As opposed to the neutral imagery condition, the age differences in average reaction rate in the positive mental imagery condition did not show any particularly clear trends. There was a slight increase in reaction rate as the age of the participants increased, although this tendency was not as pronounced as it was in the neutral imagery condition. In order to directly measure the correlation between age and response rate in the positive imagery condition, a Pearson's correlation coefficient was calculated, with $r=.664$, indicating that there was a strong correlation between the two factors, although not as strong as the correlation between age and reaction rate in the neutral mental imagery condition. A coefficient of determination value of $r^2=.441$ was observed, indicating that the age variable accounted for a reasonably large amount of the variation reaction times in this condition, even though this effect was smaller than that found in the neutral condition.

This correlation between the average rate at which participants responded to the neutral, positive, and negative stimuli was slightly stronger after participants had been exposed to the negative mental imagery scenario. These average reaction rates are displayed in Figure 4.7.

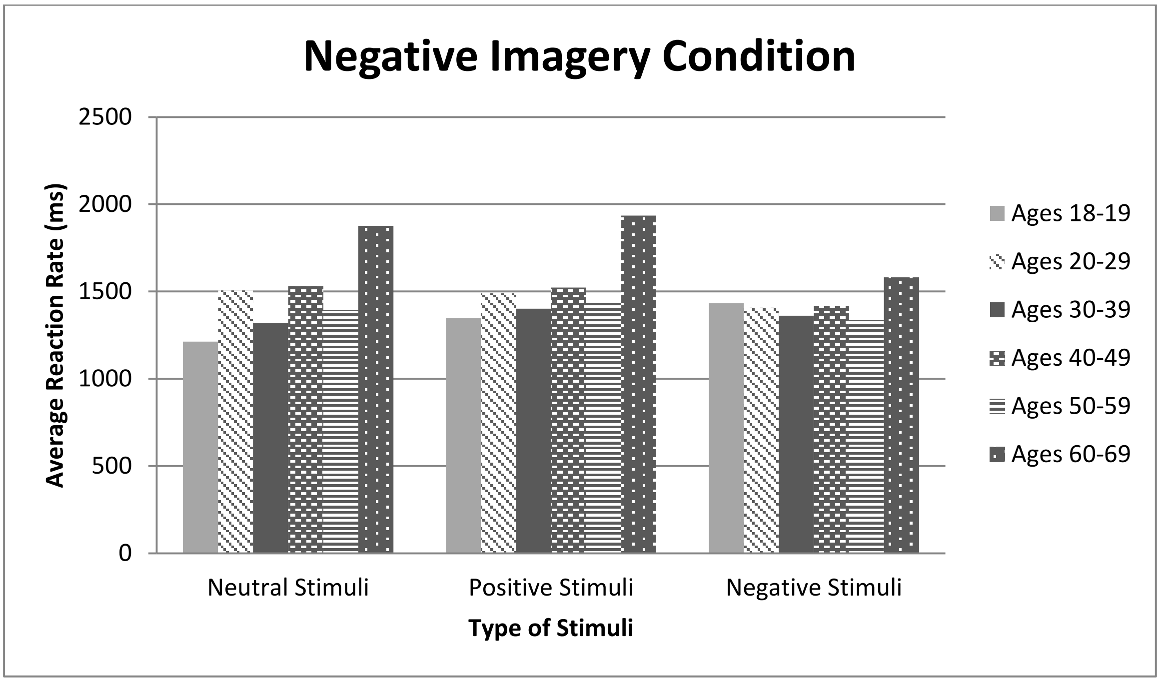

Figure 4.7: Age-related differences in reaction rate after negative mental imagery

As in the preceding two scenarios, the fastest average response rate was scored by the 18 to 19 age group, whilst the slowest average reaction rate was scored by the 60 to 69 year olds. However, in this case, the fastest reaction rate of 1213ms was in response to the neutral stimuli, whilst the slowest average reaction time was 1935ms, and was in response to positive stimuli. Overall, the average reaction times for each of the age groups, with the exception of the 60 to 69 age group, were more uniform after the negative mental imagery scenario than in the preceding two scenarios. However, despite being more equally distributed in appearance, a Pearson's correlation coefficient of r=0.728 was obtained. In other words, there was a strong positive correlation between age and the average reaction rate in the negative mental imagery condition. Whilst this r-value was not as strong as the correlation found in the neutral mental imagery condition, it is nevertheless stronger than the correlation obtained in the positive mental imagery condition. This was confirmed by a correlation of determination analysis, which yielded a value of r^2=.530, indicating that age affected the variation observed here more than it affected the positive condition, but also not as much as it affected the neutral imagery condition.

Having established that there was a positive correlation between age and the average rate at which participants responded to all three types of stimuli, and under all three conditions, it was also important to consider how many incorrect categorisations were made by each age group. This information is provided in Table 4.3.

	Ages 18-19	**Ages 20-29**	**Ages 30-39**	**Ages 40-49**	**Ages 50-59**	**Ages 60-69**
n	3	47	14	12	1	3
n Female	1	23	9	6	0	1
n Male	2	24	5	6	1	2
Total incorrect categorisations	4	147	30	28	3	9
Average incorrect categorisations	1.3	3.1	2.1	2.3	3.0	3.0

Table 4.3: Average number of incorrect categorisations per age group

As can be seen from the above table, the number of participants in each age group varied greatly. As stated earlier in this chapter, the participants were primarily clustered in the lower age groups, with over half of the participants belonging to the 20 to 29 age cohort. Out of the six age groups, only three of them (namely ages 20 to 29, ages 30 to 39, and ages 40 to 49) contained over 10 participants per group. Male and female participants were fairly evenly distributed over the six groups, with the only exceptions being the 50 to 59 age group which only comprised one male participant, and the 30 to 39 age group, in which there were considerably more females than males. In terms of the incorrect categorisations, the group with the highest number of these was the 20 to 29 age group. Despite having the highest number of participants in this age group, the 20 to 29 year olds still had the highest average number of incorrect categorisations, although this average was only slightly higher than the averages of the 50 to 59 age group and the 60 to 69 age group. Conversely, the cohort containing the 18 to 19 year olds had the lowest average number of incorrect categorisations. A Pearson's correlation coefficient of r=.612 was obtained for the correlation between age and the average number of incorrect categorisations, thereby indicating a mild correlation. In this case, r^2=.375, indicating that almost 38% of the variance observed is a result of age differences.

4.1.5 Gender differences

Before going on to look at the inferential statistics regarding whether or not there were any significant gender-related differences in reaction rate (as hypothesised in Section 2.7.2), it was essential to first have a look at some descriptive data concerning the male versus female participants. These data are represented in Table 4.4.

	Male	Female
n	40	40
Age Range	18-64	18-61
Average Age	30.9	30.1
Age Standard Deviation	11.3	9.6
Total Number of Incorrect Categorisations	144	77
Average Number of Incorrect Categorisations	3.6	1.9

Table 4.4: Demographic information of male versus female participants

As can be seen from Table 4.4, there were 40 male participants and 40 female participants in this study. The age of the male participants ranged from 18 to 64 years, with an average of 30.9 years, and a standard deviation of 11.3. The age of the female participants on the other hand, ranged from 18 to 61 years, with an average of 30.1 years, and a standard deviation of 9.6. What was interesting to notice, however, was that male participants made almost twice as many incorrect categorisations than the females did, with males having an average of 3.6 incorrect categorisations per male participant, and females having an average of only 1.9 incorrect categorisations per female participant.

In terms of average reaction rates, Table 4.6 indicates the average time in milliseconds (ms) which male participants took to respond to the various stimuli under the various conditions in comparison to female participants.

	Neutral Scenario		**Positive Scenario**		**Negative Scenario**	
	Male	Female	Male	Female	Male	Female
Neutral Stimuli	1633	1421	1559	1468	1557	1402
Positive Stimuli	1575	1453	1441	1376	1556	1427
Negative Stimuli	1634	1473	1555	1420	1478	1335

Table 4.5: Average reaction rate in ms for male versus female participants

Table 4.5 reports the average reaction rates for males versus females in each of the mental imagery conditions, and in response to each of the three types of stimuli. As can be seen from Table 4.5, male participants took longer to respond to stimuli than the female participants.

This trend held true for all of the average reaction rates to all three types of stimuli, and in all three conditions.

In the neutral mental imagery condition, males took an average of 212ms longer to respond to neutral stimuli than females. However, this difference in reaction rates dropped to an average difference of 122ms in response to the positive stimuli, and rose again to an average difference of 161ms in response to negative stimuli. Following the positive mental imagery scenario however, female participants were only an average of 91ms faster at responding to neutral stimuli than were male participants. This difference in response rate dropped even lower to an overall average difference of only 65ms in response to positive stimuli. However, when it came to responding to negatively valenced stimuli, female participants were 135ms faster than were male participants. The differences in average reaction rates increased again after participants engaged in the negative imagery scenario. Under this condition, males were on average 155ms slower to respond to neutral stimuli than were female participants. This figure decreased slightly in response to positive stimuli, with female participants being an average of 129ms faster than males. Finally, in response to negatively valenced stimuli, male participants took an average of 143ms longer than female participants.

Whilst these results of this section as well as those of the preceding section clearly indicated that engaging in either positive or negative mental imagery led to a change in response rate, a factorial ANOVA was conducted on the raw data in order to determine whether or not the differences in reaction rates were significant or not. This was explored in the next section of this chapter.

4.2 Inferential statistics

The inferential statistics conducted on the data obtained in this study were two-fold. The first procedure was a factorial ANOVA, which was carried out in order to determine whether the observed results were significant or not. The second procedure used t-tests to examine whether there were any significant gender differences in the data. Each of these two procedures will now be examined, together with the results obtained through these methods.

4.2.1 Factorial ANOVA of reaction rates

Before going on to look at the results obtained through the ANOVA, it is first necessary to establish that the base assumptions underlying ANOVA were not violated in the current data set (Fields, 2012). In terms of an ANOVA based on a linear model, there are three main assumptions: namely independence of observations, normality of distribution, and homoscedasticity. Due to the large size of the target population, it can be assumed that independence of observation remains intact, as the observations are unlikely to be affected by a common outside influencing factor. Similarly, as this study deals with reaction rates, a normal Gaussian distribution can be anticipated, meaning that this assumption also remains intact. As for the homogeneity of variance assumption, a Levene's test could not be run on the data due to the limitations of the program used to analyse the statistics.

As was mentioned in the previous chapter, a factorial ANOVA analyses the variance in a set of data with two or more factors in order to determine whether there were any significant differences in reaction times under the various imagery conditions, or whether the observed results were obtained by chance. A two-factor analysis with replication was conducted on the raw data using Excel, with the two factors being stimulus valence and mental imagery condition, with each factor having three levels. The levels of the stimulus valence factor were negative valence, positive valence, and neutral valence, whilst the levels of the mental imagery factor were positive metal imagery, negative mental imagery, and neutral mental imagery (See Appendix 6 for the full ANOVA analysis). As there were 80 sets of data with each set of data containing five positive, five negative, and five neutral stimuli after each scenario, each scenario had a total of 400 (80x5) replications. As there were three different types of stimuli, this resulted in 1200 (400x3) reaction times per scenario. As stated in the Method chapter, $p=.05$ was set as the significance level, in accordance with the power considerations of this study.

Three sets of values were obtained through the use of the factorial ANOVA: one set of values for each of the two factors, and the third set of values pertaining to the interaction between the two factors. The first set of values was indicative of the significance of the variation between the three types of scenarios, namely the neutral scenario, the positive mental imagery scenario, and the negative mental imagery scenario. A comparison of the variance between these three types of mental imagery yielded $F(2,77)=8.406$, $p=.00023$, which was much larger than the critical F value of F-Crit=2.99823, thereby indicating that the null hypothesis is not up-held. This was a clear indication that the three types of mental imagery had vastly different and significant effects on the rate at which participants reacted to the various stimuli. In terms of the effect size, an Eta^2 value of η^2=0.00463 was obtained, thereby showing that the effect is statistically significant, but weak. These values therefore supported the hypothesis that mental imagery would significantly affect the rate at which participants would react to stimuli, leading to the rejection of the null hypothesis which stated that mental imagery would not result in a significant difference in reaction rates.

The second factor analysed in the factorial ANOVA was the type of stimulus used, with the three levels of this factor being neutral stimuli, positively valenced stimuli, and negatively valenced stimuli. As the values obtained (F=1.1877, DF=2,77, p=0.3050) were not significant, it can safely be assumed that the type of stimulus used had no significant effect. These results support the trends referred to in the descriptive statistics section of this chapter: namely that when the mental imagery condition was neutral, reaction rates to all three types of stimuli were relatively equal. Taken together, these results demonstrated that reaction times were not significantly affected by the type of stimulus being responded to.

The third and final set of values obtained through the factorial ANOVA pertained to the interaction between the two factors. In other words, these values stood for the significance of the interaction between the type of mental imagery scenario and the valence of the stimulus being responded to. The ANOVA yielded F (4,75) =3.45758, p=.00794, indicating that there is a statistically significant interaction between the type of mental imagery engaged in and the valence of the stimuli. As the F-value is larger than the F-Crit, this indicates that the null hypothesis ought to be rejected. The effect size, was however quite weak, with an Eta^2 value of just η^2=0.00381 being obtained.

A Fisher's Least Significant Difference (LSD) post hoc test was calculated in order to obtain a pairwise comparison. Although it is often argued that the LSD results in inflated type 1 error rates, this only holds true when comparing more than three means (Seaman, Levin, & Serlin, 1991), which is not problematic for this study, as three means are used. Seaman et al. (1991) also found that the LSD 8% more powerful than other common post hoc tests, such as Tukey's HSD, which suggests that this post hoc analysis procedure was an appropriate analysis tool in the context of the current study. The LSD test was calculated using the formula $= t\sqrt{MSE\left(\frac{1}{N1}+\frac{1}{N2}\right)}$, and this yielded a critical value of 55.77. This critical value could then be compared to the differences between group means obtained in the ANOVA table (see Appendix 6). If the critical value was larger than the difference in group means, then this suggested that the effect observed was indeed significant. The comparisons between group means can be found in Appendix 7. According to this post hoc test, there was no significant difference in response to any of the stimuli valences after participants engaged in neutral mental imagery, as was expected. However, after engaging in positive mental imagery, there were significant differences in response to stimulus valence between neutral versus positive stimulus valences, and in positive versus negative stimulus valences. Similarly, after participants engaged in negative mental imagery, there was a significant difference between neutral versus negatively valenced stimuli, as well as a significant difference between positively and negatively valenced stimuli (for full values, please see Appendix 7).

To sum up the results obtained from the factorial ANOVA, the obtained values clearly showed that mental imagery had a very strong effect on the reaction rates of participants to the various stimuli. Furthermore, whilst the stimuli themselves had no real effect on the reaction rates, the interaction between the type of mental imagery and the emotional valence of the stimuli had an effect on the speed at which participants reacted to the various stimuli.

4.2.2 Gender-related t-tests

Table 4.6 shows the mean reaction rates (in ms) by males and females in the various conditions. As can be seen from the table, the fastest reaction rate of male participants (1440.6 ms) was in response to positive stimuli after engaging in positive imagery. Conversely, female participants were fastest in responding to negative stimuli after having read through the negative imagery scenario (1335.3 ms).

		Neutral Imagery Scenario		Positive Imagery Scenario		Negative Imagery Scenario	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Male	**Neutral Stimuli**	1632.9	539.7	1559.0	517.7	1557.2	568.3
	Positive Stimuli	1575.2	475.6	1440.6	497.4	1556.1	445.8
	Negative Stimuli	1633.6	484.3	1554.8	471.2	1477.8	634.1
Female	**Neutral Stimuli**	1421.0	453.6	1468.0	488.1	1402.2	405.0
	Positive Stimuli	1452.9	338.7	1376.0	509.2	1426.9	361.7
	Negative Stimuli	1472.6	401.7	1420.4	384.3	1335.3	480.6

Table 4.6: Mean and Standard Deviation differences between genders in ms

In order to determine whether there were any gender differences in the reaction rates beyond those seen in the above descriptive statistics, nine independent t-tests were conducted on the scores (see hypothesis in Section 2.7.2). As previously stated, although these data could have been analysed using a 3-way ANOVA, this was not possible in the current study due to the limitations of the analysis program used. The values of these t-tests are presented in Table 4.7.

	Neutral Imagery Scenario				Positive Imagery Scenario				Negative Imagery Scenario			
	p	t	df	d	p	t	df	d	p	t	df	d
Neutral Stimuli	.0000*	4.25	398	.991	.0710	1.81	398	.409	.0018*	3.14	398	.722
Positive Stimuli	.0032*	2.96	398	.679	.2004	1.28	398	.288	.0016*	3.18	398	.732
Negative Stimuli	.0003*	3.62	398	.840	.0019*	3.13	398	.718	.0124	2.51	398	.572

Table 4.7: t-test and Cohen's d values comparing gender differences in reaction rates

As was mentioned in Chapter 3, the use of multiple comparisons does increase the risk of cumulative error, thereby necessitating a Bonferroni Correction. With an alpha value of 0.05 and a total nine t-tests being performed, this means that the chance of finding significant differences in nine tests is 36.98%. Thus, a Bonferroni's adjustment would lower the alpha value to 0.006 (obtained by dividing the original alpha value of 0.05 by the number of comparisons, so 0.05/9). Cohen's d was also calculated for the various tests, as this is an indicator of the size of the effect, which is useful in determining how strong the phenomenon under study really is. Values in Table 4.7 which comply with the Bonferroni adjustment are marked by an asterisk

After participants were exposed to the neutral imagery scenario, Table 4.7 indicates that there was a significant difference in how males and females reacted to neutral, positive, and negative stimuli. This difference was particularly great in terms of the reaction rate to neutral stimuli, with males (M=1632.9, SD=539.7) being slower than females (M=1421.0, SD=453.6) t (398) =4.25, p=.00003, and Cohen's d=.9913. The difference between the two genders in their reaction rates to negative stimuli was also highly significant: on average males (M=1633.6, SD=484.3) were again slower than females (M=1472.6, SD=401.7), t (398) =3.62, p=.00033, and Cohen's d=.8401. This difference in reaction rates was not as pronounced in response to positive stimuli, with females (M=1452.9, SD=338.7) being slightly faster than males (M=1575.2, SD=475.6), t (398) =2.96, p=.00323, whilst the Cohen's d value was d=.6795, with DF=39.

After the participants had been exposed to the positive mental imagery scenario, these differences in reaction rates between male and female participants diminished. When the reaction rates of male (M=1559.0, SD=517.7) versus female (M=1468.0, SD=488.1) participants in response to neutral stimuli following the positive mental imagery scenario were compared, t (398) =1.81, p=.07104 was observed, indicating that there was no significant difference between how male and female participants reacted to the neutral stimuli. There was also no significant difference in terms of male (M=1440.6, SD=497.4) and female (M=1376.0, SD=509.2) reaction rates to positive stimuli, with t (398) =1.28, p=.20042. However, there was a significant difference between how males (M=1554.8, SD=471.2) and females (M=1420.4, SD=384.3) responded to negative stimuli after having been exposed to positive mental imagery, as is indicated by t (398) =3.13, p=.00190, with Cohen's d being d=.7188.

Once the negative mental imagery scenario had taken place, the differences in reaction rates between male and female participants increased again. As in the neutral imagery condition, the differences between males and females in response to all three types of stimuli were significant. When comparing the reaction rates of male (M=1557.2, SD=568.3) and female (M=1402.2, SD=405.0) participants in response to neutral stimuli, this yielded a value of t (398) =3.14, p=.00180. In addition to this, an effect size (Cohen's d) of d=.7228 was obtained, indicating that this difference was very large. The difference in the reaction rates to positive stimuli between male (M=1556.1, SD=445.8) and female (M=1426.9, SD=361.7) participants was also very large, with t (398) =3.18, p=.00158, and an effect size of d=.7322. The difference between the two genders in response to negative stimuli was slightly smaller, with males (M=1477.8, SD=634.1) being slower than females (M=1335.3, SD=480.6), t (398) = 2.51, p=.01244, and with a Cohen's d of d=.5723. However, although the effect size is still relatively strong, the p-value was just above the adjusted alpha value, indicating that this difference was not significant. Thus, although not statistically significant in this study, further studies with a larger sample size may find a statistically significant difference.

To summarise, these results suggest that males and females differed significantly in their response rates to the various stimuli and under the various imagery conditions. The only exceptions to this were the responses to neutral and positive stimuli after the participants had engaged in positive mental imagery, as well as to negative stimuli after the negative imagery condition.

In conclusion, this chapter has shown that the stimuli used in this experiment were relevant to the study. Furthermore, it was found that engaging in mental imagery does affect the reaction rate to emotionally valenced stimuli. However, what was not looked at in this chapter is the meaning of the results. Thus, the implications of the results and the inferences which can be drawn from them are further considered in the following chapter.

CHAPTER 5
DISCUSSION, RECOMMENDATIONS, AND CONCLUSION

Whilst the results observed in this study are unique, they do coincide to some degree with results of other studies. This chapter therefore presents a critical appraisal of the results obtained in this study, and also compares these results with the findings of past studies. This chapter also details both the contributions and possible applications of the findings, as well as the limitations of the current study.

5.1 Summary of the study

Before going on to look at the various results and their implications, this chapter begins with a summary of the previous sections of this study, whose primary aim was to investigate whether engaging in positive mental imagery could influence the rate at which participants reacted to positive stimuli, and, in a similar vein, whether negative mental imagery could cause a difference in the reaction rate to negatively valenced stimuli. Put concisely, this study was primarily aimed at investigating whether different types of mental imagery had an effect on the reaction rate with which participants responded to emotionally valenced stimuli. Secondary aims of this study included examining the effects of age and gender on these reaction times in order to gain a better understanding of how such variables influence the interaction between the type of mental imagery and the rate at which a person reacts to emotionally valenced stimuli.

The literature review individually explored each of the concepts contained in this study, and also focused on the intersections between the various concepts where such information was available. However, as pointed out in the literature review, very little information was found documenting the interactions between mental imagery and reaction rates to emotionally valenced stimuli, thereby further demonstrating the need for a study such as this one.

The study was exploratory in nature, and used a quantitative approach to address the research questions. The sample consisted of a total of 40 male participants and 40 female participants selected from different age groups and different socio-economic status groups in order to obtain results which were as generalizable as possible. Each participant completed a specifically designed computer program in which he or she was asked to respond as fast as possible to neutral stimuli, positively valenced stimuli, and negatively valenced stimuli, after having engaged in neutral mental imagery, positive mental imagery, and negative mental imagery. The primary hypothesis (see 2.7.3 in Chapter 2) stated that engaging in negative mental imagery would bias a person towards negative stimuli, as demonstrated by an increase in the speed at which participants responded to negative stimuli relative to positive or neutral stimuli. Similarly, it was further hypothesised that engaging in positive mental imagery would result in a bias towards positively valenced stimuli, which would result in participants being faster to react to positive stimuli than to neutral or negative stimuli. In the control condition, the hypothesis stated that neutral imagery would not bias response rates to any particular type of stimulus, resulting in similar response rates to all three types of stimuli. The secondary hypotheses being tested concerned differences in response rates caused by age differences and gender differences (formally set out in Sections 2.7.1 and 2.7.2 in Chapter 2 respectively). Thus, one secondary hypothesis stated that there would be an age-related difference in response rates with younger participants being faster than older participants, whilst the other secondary hypothesis stated that gender differences would result in different reaction rates for the two genders.

The raw data obtained from the computer program were analysed using various Excel formulae. The relevance of the stimuli used in the study as well as their applicability to a South African population was examined using descriptive statistics. On the one hand, age-related effects on reaction rates were explored using both descriptive statistics as well as Pearson's correlation coefficients. On the other hand, however, the gender-related effects on reaction rates were explored using both t-tests and Pearson's correlation coefficients. The main hypotheses concerning the effects of mental imagery on the reaction rate to emotionally valenced stimuli were verified using a factorial ANOVA. Whilst the results of the analyses were presented in the previous chapter, their implications were not fully expounded, and these shall be fully explored in the following section.

5.2 Discussion of the results

The results obtained in the previous chapter shall now be expanded on in the order in which they were presented in the fourth chapter. The implications of the results shall be further discussed, and how the present findings fit in with previous research shall also be taken into consideration.

5.2.1 Stimuli

The stimuli used in this study were taken from the ANEW list based primarily on the valence scores of each word reported in the ANEW list. However, as was mentioned in section 4.1.1 in Chapter 4, these valence scores were calculated using an American sample. Whilst care was taken to select words which are not culture-specific, and which are biologically relevant, and which should therefore be relevant to all humans, the amount of incorrect categorisations indicated that the stimuli are not completely applicable to a South African sample, which in turn could have ramifications for the amount of measurement error obtained in the results. However, some inter-cultural variation is expected, and the degree of discrepancy between American norms and the valence allocated to the same stimuli by a South African sample is not so large as to invalidate the results drawn from the data obtained in this study. Additionally, it must be kept in mind that the instructions given in the computer program specified that participants should respond to the stimuli as fast as they could. This may have skewered the speed-accuracy trade-off so that a greater number of mistakes were made in order to increase the speed at which the participants responded to the stimuli. In other words, as participants were asked to categorise the stimuli as fast as possible, this may have resulted in a heightened number of incorrect categorisations than if the participants had been instructed to categorise the stimuli at their own pace. Thus, it is necessary to view those stimuli which were incorrectly categorised once or twice as possible mistakes. For example, it may have been that stimuli such as “abuse” or “disaster” were incorrectly categorised not because one of the participants believed that these stimuli do not belong in the negative category, but because a participant may have accidentally pressed the “neutral” or “positive” button. However, whilst some incorrect categorisations may be due to error, it is not possible to ascribe multiple incidents of an incorrect categorisation of the same stimulus to error. Stimuli such as “cash”, “rain”, and “baby” were incorrectly categorised a total of 23, 25, and 19 times respectively. This suggests that there is a discrepancy between the American valence norms and the valence which the South African sample in this study allocated to these stimuli. This in turn illustrates that, whilst the American norms may be helpful in guiding hypotheses regarding South African samples, it is nonetheless essential for future research to establish valence and arousal norms based on South African samples. However, it is also possible that some of these differences in stimulus categorisation may be due to the wants and needs of the individual at the time of observation. As discussed in section 4.1.2 in Chapter 4, the sample studied in this research was clustered in the younger age groups, with over half of the sample being in the 20 to 29 age group. It may therefore be that concepts which were reported as having a positive valence in the ANEW list may change over the duration of a person's lifetime. For example, it is possible that the valence of stimuli such as "cash" and "baby" may change with the stage of life in which the individual finds himself or herself. Thus, it may be that starting a family and having the financial means to support a family may not be as important to a person in the 20 to 29 age group as it is to a person in the 30 to 39 age group. Consequently, it is possible that a younger age group would classify stimuli such as "cash" and "baby" as being neutral, whilst an older age group would be more likely to categorise these stimuli as positive, or that females would rate "baby" as being more positive than men, due to inherent motherly instincts. It is also possible that cultural differences are largely the cause of the discrepancies in the emotional valence allocated to the stimuli. For example, as droughts are a very real occurrence in Africa, it could be that "rain" was rated as being more positive by the South African participants, as rain is perceived as something that enables crops to grow. Similarly, it is possible that other stimuli, such as "cash" are rated as less positive due to changes in the way money transactions are made. In other words, stimuli such as "cash" may be less relevant in the electronic era than other related but more current stimuli, such as "credit card" for instance.

It was interesting to note that positive stimuli and neutral stimuli both had a total of 96 incorrect categorisations, whilst the stimuli which were negatively valenced were only incorrectly categorised 29 times, less than a third as frequently as the positive and neutral stimuli. This suggests that there is much greater intercultural agreement on what constitutes a negative stimulus, with much greater variability in opinion over whether a positive stimulus really is positive, or whether a neutral stimulus is really neutral. According to Robinson, Storbeck, Meier, and Kirkeby (2004), when a person is initially encoding a stimulus, and if the stimulus is found to be arousing, then the stimulus will automatically be assumed to have the potential to be dangerous. If, however, the stimulus is not highly arousing, then it will be assumed to be safe. Thus, the level of the arousal of the stimulus influences whether the stimulus can be approached or whether it should be avoided, with moderate levels being linked to an approach reaction, and higher levels triggering an avoidance reaction. These claims made by Robinson et al. (2004) illustrate that people are more receptive to negative stimuli, with the results of the current study indicating not only that people are more sensitive to negative stimuli, but also that, in this case at least, there was greater cross-cultural agreement as to what constitutes a negative stimulus than what constitutes a positive or a negative stimulus. It was, however, interesting to note that "suicide" was the most frequent incorrectly categorised negative stimulus. A possible explanation for this draws on the conclusions put forward by Robinson et al. (2004), namely that dangerous stimuli are highly arousing, triggering avoidance of the stimuli. In the case of "suicide", it could be that the concept of suicide is not seen as negative as it is not a threat to one's biological integrity per se. In other words, suicide is a conscious and pre-meditated decision to end one's own life, and is therefore something a person voluntarily engages in. Other negative and biologically relevant stimuli, such as "terrorist", "abuse", or "torture", are possibly more likely perceived as a threat as they are caused by an external agent, and are therefore perhaps more likely to be rated as being negative. An alternative explanation is that the act of committing suicide is not as taboo as it once was, and that this wider acceptance could be an influencing factor on why the stimulus "suicide" was the most incorrectly categorised negative stimulus.

5.2.2 Participant demographics

After having analysed the statistics relevant to the stimuli used in the study, the next set of results related to participant demographics was examined. The demographics pertaining to the participants illustrated that the sampling technique used was effective in collecting data from a variety of age groups, and from both genders. However, because fluency in English was one of the selection criteria used to choose participants, the participants came from a homogenous language group, although there was variation in the cultural groups from which the participants were selected. In addition to this, recruiting participants from various socio-economic status groups ensured that the sample used in this study was highly representative of the non-clinical South African adult population. Furthermore, as the sample was drawn from different strata in the general population, the external validity of this study was relatively high, thereby ensuring that the sample was representative of and generalizable to the general population of non-clinical English-speaking adult South Africans (Cozby, 2005).

As Cozby (2005) also points out, two advantages of convenience sampling are that convenience samples induce smaller costs than randomised sampling procedures, and the convenience samples are also faster to obtain. Therefore a convenience sample was used for the current study. Nevertheless, it must be noted that this study did violate one of the base assumptions of ANOVAs, namely randomisation of participants, so the conclusions drawn from these results can only be seen as tentative.

With regard to the sample size used, as this research was explorative in nature, it was not necessary to have an overly large sample size. In other words, as the primary aim of this study was to test the hypotheses outlined in the first chapter, the sample size needed only to be large enough to confirm whether the expected trend would be observed or not. Furthermore, as stated by Hoppitt et al., (2010), much of the research done in the field of CBM has used small samples, with the sample size used in the current research being comparable to the sample sizes used in other CBM studies. Nevertheless, the sample size was large enough to yield some idea of how cognitive bias modification affects mental imagery.

Furthermore, the constraints governing the sample selection increased the fittingness of participants. This information, combined with the suitability of the stimuli used, indicates that both the method through which the raw data were obtained, as well as the sample population from which the raw data were drawn were both as valid as possible for addressing the hypotheses which were explored in the current study.

5.2.3 Average reaction rates

As care was taken to increase the validity of the method of analysis, it can be inferred that the results obtained ought also to be fairly valid. The findings of the current study were to some extent consistent with those observed by Kousta et al. (2009), who also found that positively and negatively valenced words were recognised faster than neutral words. Whilst Kousta et al. (2009) found reaction rates to negatively valenced words to be the fastest at 568ms, positively valenced words were slightly slower, with an average reaction rate of 570ms. Neutral words were found to be significantly slower, taking an average of 593ms. However, it must be kept in mind that these results were found using verbal processing, rather than the mental imagery processing used in the current study. The current study found that, overall, the average reaction rate to neutral stimuli constituted the slowest response rate, taking an average of 1502ms; this is consistent with the results obtained by Kousta et al. (2009) who also found reaction rates slowest to neutral stimuli. However, as opposed to the findings of Kousta et al. (2009), the findings of this research indicated that the average reaction rate with which participants responded to positively valenced stimuli was actually faster than the average rate at which participants responded to negatively valenced stimuli, with average rates being 1473ms and 1481ms respectively. Nonetheless, the difference between these two average reaction rates is very small, as was also the case in the findings reported by Kousta et al. (2009). It must be noted that the large discrepancies between the average reaction rates in this study versus the research conducted by Kousta et al. (2009) are due to the nature of the tasks: in the Kousta et al. (2009) study, participants were required to judge whether a string of letters presented a word or a non-word before pressing a button. However, in the current study, participants were required to read each stimulus, to make judgements about the valence of the stimuli, to decide whether the stimuli were neutral, positive, or negative, and then finally to click the appropriate button. Thus, as the current study involved more steps than the Kousta et al. (2009) study, reaction times were slower in the current research.

One of the contributions of this study was to provide evidence in the discrepancies between the findings of Kuhbandner et al. (2009), who found that participants were faster at recognising negative rather than positive stimuli due to faster bottom-up processing relative to top-down processing, and the findings of Hoppitt et al. (2010) who found that the healthy, non-clinical population has a slight bias towards perceiving positive stimuli as this helps to shield them from negative emotions. As one of the primary reasons for including the neutral imagery condition in this study was to act as a control condition aimed at identifying pre-existing biases, the results from this condition provided some additional information. After the neutral imagery scenario, participants reacted to neutral stimuli at an average rate of 1527ms, whilst the average reaction rate to positive stimuli was 1514ms, and the average reaction rate to negative stimuli was 1553ms. In other words, on average, participants were slowest at responding to positive stimuli, and fastest at reacting to negative stimuli. These findings support those of Kuhbandner et al. (2009), and provide support to their hypothesis that bottom-up processing of stimuli results in a faster reaction rate to negative stimuli than to positive or neutral stimuli. However, it must be noted that, in the context of the current study, the difference in average reaction rate between response time to positive stimuli and response time to negative stimuli was only 39ms. Thus, the advantage in processing speed of negative stimuli over positive stimuli was very small. As such, the differences between the reaction rates to neutral, positive, and negative stimuli are so small that one can conclude that the sample observed in this study did not have any pre-existing biases.

As there were no pre-existing biases found in this study, this contributes to the debate as to whether biases cause the emotional state, or whether the emotional state causes the biases (Hoppitt et al., 2010). If the first option had been true, namely if biases had caused the emotional state, then there would have been greater differences in the reaction rates in the neutral mental imagery condition. In other words, as no alteration of emotional state occurred in the neutral imagery condition, then any pre-existing biases would have manifested in diverging sensitivities to the three different types of stimuli presented after the scenario. The absence of such diverging reaction rates indicates that there were no pre-existing biases influencing the results. As such, the results of the current research support the second option, namely that the emotional state causes the biases. The manipulation of the emotional state of the participants through the use of positive and negative mental imagery resulted in significant increases in the sensitivity to positive and negative stimuli respectively. From this, it is possible to conclude that positive mental imagery biased the participants towards responding to positive stimuli, whilst engaging in negative mental imagery created a bias towards negative stimuli. The current research therefore goes some way in providing empirical evidence in the debate mentioned by Hoppitt et al. (2010), and further illustrates that a person's emotional state can be manipulated in order to induce a bias towards certain types of stimuli over others.

5.2.4 Age-related reaction rates

The next question which was addressed was related to how various types of mental imagery affect the reaction rate to emotionally valenced stimuli as a function of age (as set out in Section 2.7.1 in Chapter 2). In other words, did the reaction rate change as a person got older, and if so, how did it change? The analysis of the age-related reaction rates indicated that there was a positive correlation between the age of the participants and the rate at which the participants responded to the stimuli, meaning that the older a participant was, the longer that participant took to respond to the stimuli. The strength of the correlation varied from strong in the neutral imagery scenario, to moderate in the positive mental imagery scenario, and back to strong in the negative imagery scenario. This indicates that as a person ages, the rate at which that person responds to stimuli after engaging in any of the three types of mental imagery increases substantially. It has been well documented that several cognitive capabilities decline with increasing age (Cavanaugh & Blanchard-Fields, 2011), and in light of this, these findings are not surprising.

The strong correlation observed after the neutral imagery scenario indicates that older adults typically respond to stimuli more slowly than do younger adults. This control condition was specifically designed to establish whether or not there were any pre-existing biases, with results indicating that there were no significant biases prior to the experimental conditions. Thus, it can be claimed that in the absence of any cognitive biases, older adults take longer to respond to various stimuli than younger adults. Similarly, the strong correlation between age and response rate after the negative mental imagery showed that older participants took longer to respond to stimuli after the negative imagery scenario than younger participants. What was interesting was that the correlation between age and reaction time was less strong after the participants had engaged in positive mental imagery. From the results obtained, one can see that response rates to various stimuli after engaging in positive mental imagery were fairly uniform for the various age groups, with age only having a moderate effect on reaction rates. This suggests that age-related differences in reaction rate are affected differently by the various types of mental imagery, with less of a difference observed when participants engage in positive mental imagery than if they engage in neutral or negative mental imagery.

But this raises the question as to what causes these age-related differences in reaction rate. One possibility is that the effects of increased age are linked to the accuracy speed trade-off, whereby younger adults are faster at making decisions than older adults, but make more mistakes than older adults. The findings in this study partially support the claims of Starns and Ratcliff (2010), who state that, on the one hand, older adults typically make more accurate decisions than younger adults, but on the other hand, younger adults are faster at making decisions than their older counterparts. An analysis of the results based on performance levels per age cohort did indeed support the notion that younger adults were faster than older ones: the correlation coefficients calculated in section 4.1.4 in the previous chapter clearly show that there was a positive correlation between age and the speed with which the participants responded to the stimuli. However, Starns and Ratcliff (2010) also claim that older adults make more accurate decisions than younger adults, a notion only moderately supported by the current findings. More specifically, a look at the average number of incorrect categorisations which occurred in the current study indicated that the youngest age group in this study had the lowest average number of incorrect categorisations, whilst the two oldest age groups had the second highest number of incorrect categorisations. Nevertheless, age and the average number of incorrect categorisations obtained a correlation coefficient of r=.612, showing that there is a moderate correlation between the two factors. It is possible that the uneven distribution of participants across the six age groups could have resulted in a weaker correlation than the expected correlation. In other words, if this study had had a larger sample which was more evenly distributed among the various age groups, then it is possible that the correlation coefficient observed for the interaction between age and the average number of incorrect categorisations would have been stronger, thereby providing more support for the statement made by Starns and Ratcliff (2010).

With regard to the question as to how it is that such age-related differences in reaction rate exist, Starns and Ratcliff (2010) suggest that differences in the speed at which younger and older adults complete decision-based tasks is caused by a difference in the degree of the conservativeness which they adopt. In other words, when faced with making a decision, older adults typically spend a greater amount of time gathering information about a decision in order to make more accurate choices than do younger adults. In the context of the current study, this would suggest that the older participants spent more time considering their experiential knowledge regarding the stimuli than younger participants. Whilst this did enable older participants to make slightly more accurate categorisations, this strategy also put older participants at a disadvantage in terms of reaction speed. The findings of the current study support the notion that older adults are more conservative in their decisions than younger adults, as was indicated by the high correlation between age and average reaction rate, as well as the moderate correlation between age and accuracy.

However, an alternative explanation by which these age-related differences can also be elucidated is through the variances in speed of processing theory. Cavanaugh and Blanchard-Fields (2011) state that the speed of processing, namely the speed and the efficiency with which early steps in information processing are carried out, is affected by age, with many early stages of information processing taking longer as a person gets older. Information about the valence of a stimulus is one of the first features which are encoded when processing a stimulus, and this information is available in the earliest stages of information processing (Robinson et al., 2004). Taken together, this suggests that because the speed at which certain early stages of processing are completed is negatively correlated with age, it is possible that the reaction rates of older participants in this study were affected by this decline in the speed of processing. In other words, as information about stimuli valence is present in the earliest stages of information processing, and as these first stages often take longer in older adults, and because the task in this study required participants to categorise the stimuli according to their valence, it could be that the younger participants were faster at categorising stimuli as they were able to complete the early stages of information processing at a faster rate than older adults.

Thus, whilst it is not exactly clear why such age-related differences in reaction rate exist, it is nevertheless undeniable that such age-related differences do exist. Having examined the implications of the results obtained from the descriptive statistics, it is time to look at the meaning of the results pertinent to the main aim of this study: did mental imagery have an effect on the reaction rate to emotionally valenced stimuli?

5.2.5 Factorial ANOVA

The primary aim of this study was to examine the hypotheses that engaging in negative imagery made a person more sensitive to negative stimuli, and that positive mental imagery enhanced a person's sensitivity to positive stimuli (as was indicated in Section 2.7.3 of Chapter 2). The results of the factorial ANOVA support these hypotheses, and indicate that mental imagery does indeed increase the speed with which a person responds to emotionally valenced stimuli. The first analysis was representative of the degree to which the variance between participants' reaction rates to emotionally valenced and neutral stimuli was affected by the type of mental imagery scenario. The results found (F=8.4057, DF=2,77, p=.0002) indicated that the type of mental imagery engaged in had a very noteworthy effect on how participants responded to stimuli. This finding is of central importance to this study, as it shows that the differences in the reaction rates between scenarios were likely to be caused by the scenarios themselves, rather than by a confounding factor. These results were supported by a post hoc test, discussed more fully below.

Also central to this direct claim of causality is the second analysis which represented the significance of the variation in response rates caused by the different types of stimuli. In other words, this analysis denoted the degree to which changes in the reaction rates of the participants were caused by the valence of the stimulus. This ANOVA yielded (F=1.1877, DF=2,77, p=0.3050), suggesting that the emotional valence had no significant effect on the rate at which the participants reacted to the stimuli in the various mental imagery conditions. When the first two ANOVA statistics are considered together, they show without doubt that the rate at which participants responded to the various stimuli was dependent on the type of mental imagery in which the participant had engaged in, and not dependent on any other single factor, such as the inherent characteristics of the emotionally valenced stimuli. Thus, as a separate factor, the emotional valence of the stimuli would not have had a strong enough effect to influence the rate at which participants responded to the stimuli. In other words, the emotional valence had a necessary but not sufficient effect on the rate at which participants reacted to the stimuli.

The third and final ANOVA investigated the interaction was representative of the interaction between the two factors: in other words, this value was indicative of the degree to which the reaction rates were influenced by the type of mental imagery engaged in, and the emotional valence of the stimulus responded to. This analysis yielded (F=3.4576, DF=4,77, p=.00794), providing support for the hypothesis that the effect which each mental imagery scenario had on the reaction rate of the participants was tempered by the type of stimulus to which the participants were reacting. In other words, there were statistically significant differences in the variance between the reaction rates in the various conditions, and this variance was concurrent with the type of stimulus being responded to. From this result, it is possible to infer that different types of mental imagery affected reaction rates to different types of emotionally valenced stimuli in varying ways.

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However, it is not sufficient to know that the interaction between the two factors was significant, one must also know how this interaction manifested itself. Put another way, it is vital not only to know that the interaction between the type of mental imagery and the emotional valence of the stimulus is significant, but it is important to look at how this affected each of the conditions separately. This may be inferred based on the averages presented in the ANOVA table (see Appendix 6 for the full ANOVA table).

Following the neutral imagery condition, the average reaction rates to neutral stimuli and positively and negatively valenced stimuli were all fairly equal. If one considers this in combination with the insignificant p-value for the influence of the emotional valence of the stimuli, one comes to the conclusion that neutral mental imagery had no effect on the reaction rate of participants to emotionally valenced stimuli of any kind. These findings support the hypothesis underlying this section, namely that the average reaction rate of the participants to neutral, positively valenced, and negatively valenced stimuli would be similar. This in turn supports the use of this condition as a control condition, as the neutral mental imagery did not have any effects on any of the reaction rates, thereby allowing the average reaction rates to be used as a base-line against which the reaction rates in the experimental conditions could be compared.

After having engaged in the positive mental imagery, the average reaction rates of the participants were noticeably different to those obtained in the control condition. The average reaction rate to neutral stimuli remained similar to the reaction rate to neutral stimuli in the neutral imagery condition, thereby suggesting that this reaction rate had not been significantly affected by positive mental imagery. However, the average reaction rate of the participants to positive stimuli was much lower in the positive mental imagery condition than that in the neutral imagery condition. From this, one can conclude that engaging in positive mental imagery biased the participants to positively valenced stimuli, resulting in a faster reaction time to the positively valenced stimuli. The average reaction rate to negatively valenced stimuli on the other hand was less than the reaction rate to negative stimuli in the control condition, but notably slower than the average reaction rate to positive stimuli in the positive mental imagery condition. These results therefore suggest that mental imagery increases the speed at which both positive and negative stimuli are responded to, although this increase is far more noteworthy in the case of positive stimuli than in the case of negative stimuli. The hypothesis underlying this condition was that engaging in positive mental imagery would increase the rate at which participants responded to positively valenced stimuli relative to the rate at which they would respond to neutral or negatively valenced stimuli. This hypothesis was clearly supported, and the factorial ANOVA did indeed show that there was a significant difference in the speed at which participants categorised the positively valenced stimuli when compared to other stimuli. What was surprising, however, was the slight increase in the rate at which participants responded to the negatively valenced stimuli.

The negative mental imagery condition was set up in order to test the hypothesis that engaging in negative mental imagery would result in a faster reaction rate to negatively valenced stimuli relative to positively valenced and neutral stimuli. An examination of the average reaction rates to the various stimuli in this condition showed that the slowest response rate was that to positively valenced stimuli, which was slightly slower than the average response rate to neutral stimuli. This was unexpected, as it was hypothesised (see Section 2.7.3) that the reaction rates to neutral stimuli would not be affected by any type of mental imagery. However, an alternative explanation for these results is that, as opposed to negative mental imagery slightly increasing the average reaction rate to neutral stimuli relative to positive stimuli, it is possible that the reaction rate to positive stimuli was slowed by the negative mental imagery to the point where the reaction rate to positive stimuli exceeded the reaction rate to neutral stimuli. This may help to explain why people suffering from depression engage with positive and negative information differently to how non-depressed people engage with information. Levens and Gotlib (2010) found that individuals suffering from depression were slower at disengaging from negative information than people without depression, possibly indicating a reduction in the ability to update negative representations in working memory with positive or neutral ones, leading to perseveration of negative affect. Conversely, non-depressed individuals were slower at disengaging from positive information.

The results of the current study support Levens and Gotlib's (2010) claim concerning non-depressed individuals, and indeed show that participants were slow to disengage from positive information, but only following the negative mental imagery scenario. Following the positive mental imagery, participants in the current study were faster at disengaging from positive information than negative information, as can be inferred from the faster reaction rates to positive stimuli relative to negative stimuli. This seems to suggest that the claims made by Levens and Gotlib (2010) about non-depressed individuals may be too generalised, and that a more in-depth examination of the differences between depressed and non-depressed participants in the rates at which people disengage from positive and negative information after engaging in various types of mental imagery is necessary for a fuller understanding of how depression works. However, it remains unclear as to why negative mental imagery affected response rates to neutral stimuli, although it could also be theorised that engaging in mental imagery also slows reaction rates to neutral stimuli, rather than just merely increasing the rate at which negative stimuli are reacted to.

The results in the negative mental imagery scenario also showed that the response rate to negatively valenced stimuli was greatly affected by the negative mental imagery. In fact, the response rate of participants to negatively valenced stimuli in the negative mental imagery condition represented the overall fastest response rate. This in turn indicates that engaging in negative mental imagery makes a person more responsive to negative stimuli than the increase in responsiveness to positive stimuli caused by engaging in positive mental imagery. Moreover, the finding that negative mental imagery results in a bias towards negatively valenced stimuli unambiguously supports the theory that negative cognitive biases play a role in the maintenance of emotional disorders such as depression (Holmes et al., 2009; Mcleod et al., 2009; Lang et al., 2012). This theory states that a negative cognitive bias goes some way in explaining the causality of depression, with cognitive theories of depression ascribing the onset and the maintenance of depression to a negative interpretation bias (Lang et al., 2012), as discussed in section 1.4 of Chapter 1. This direct link between negative mental imagery and negative cognitive biases is vital not only to the understanding of how emotional disorders such as depression are maintained, but it also provides insights as to how new treatments can be created to combat such disorders.

The results found through the ANOVA analysis were further strengthened through the use of Fisher's LSD test. As can be seen in Appendix 7, there were no significant difference in reaction rates to the differently valenced stimuli following the neutral mental imagery condition. This was as expected, with the hypothesis set out in 2.7.3 stating that neutral imagery ought not to bias response rates to any particular type of stimulus, resulting in similar response rates to all three types of stimuli. In terms of the effect of positive mental imagery, it was hypothesised that positive mental imagery would bias responses towards positive stimuli, whilst not biasing response rates to negative or neutral stimuli (see Section 2.7.3 for hypothesis). The post hoc test on the ANOVA values revealed a significant difference in response rates between neutral versus positive stimuli, and in positive versus negative stimuli, but failed to find a significant difference between negative and neutral stimuli. This again completely supports the hypothesis; positive mental imagery increased reaction rates to positive stimuli, but did not bias response rates to negative and neutral stimuli in this condition. Finally, in terms of the predictions underlying the negative mental imagery condition, it was hypothesised that engaging in negative mental imagery would bias responses to negatively valenced stimuli, but that positive and neutral stimuli would remain unbiased (again, see Section 2.7.3 for hypothesis). Once again, this hypothesis was fully supported by the results of the post hoc test: there was a significant difference in reaction rates between neutral versus negative stimuli, as well as between positive and negative stimuli, but there was no significant difference between positively and neutrally valenced stimuli. In other words, there was a clear indication that negatively valenced stimuli had been biased in the negative mental imagery condition; an effect not seen for either positively or neutrally valenced stimuli. Thus, overall, the findings of the ANOVA and the post hoc LSD test completely supported the hypotheses made.

Having concluded that engaging in mental imagery does indeed result in a bias towards processing certain stimuli faster than other stimuli, the question arises as to why this biasing occurs. Markman and Gentner (2005) noted that categorisation of stimuli involves a typically spontaneous drawing of similarities between the presented stimulus and stored category representations, as recognition of similarity allows a person to make generalisations about similar objects, thereby reducing the amount of cognitive resources needed to process a new stimulus. In other words, when deciding on which category to allocate a certain stimulus, participants first compared the presented stimulus with any pre-existing category representations which the participant already had. Moreover, similarities between stimuli may enhance cognitive processing by allowing certain properties of the stimuli to be more readily accessible. This cognitive bias allows new situations to be compared to past experience, which allows the person to make faster inferences about the new situation (Markman & Gentner, 2005), which is clearly advantageous from an evolutionary perspective. However, as stated by Lang et al. (2012), cognitive biases may become maladaptive, and this may play a role in the development of emotional disorders. However, given the recency of this field of study, further research into the exact mechanics underlying this phenomenon is necessary.

5.2.6 Gender data

Having looked at the results of the inferential statistics pertaining to the effects of mental imagery on overall reaction rate to emotionally valenced stimuli, it is time to discuss the results concerning one of the secondary aims of this study: namely, the gender related differences in the data obtained. As was discussed in Section 2.7.2, the hypothesis underlying this research aim was that there would be a difference in the rate at which males and females responded to emotionally valenced stimuli after engaging in mental imagery. These statistics not only reported how many incorrect categorisations were made by male participants relative to female participants, but also conveyed information regarding the average reaction rates at which the two genders responded to the stimuli used in the study.

Firstly, as can be seen in the descriptive statistics in section 4.1.5 in Chapter 4, males made almost twice the number of incorrect categorisations than did females. It is possible that the difference in the number of incorrect categorisations made between males and females may reflect a possible gender bias in the ANEW list. However, it may also indicate that males allocate a different valence to stimuli. Wager, Luan Phan, Liberzon, and Taylor (2003) point out that males process emotional information differently to females, with females having a stronger psychophysiological response to emotional stimuli than males. This may suggest that, in the case of the current study, female participants were able to categorise stimuli more correctly as their reaction to the emotionally valenced stimuli was stronger, and therefore less ambiguous, than the responses of male participants. Indeed, structural imaging studies have indicated that the cingulate cortex of females contains more grey matter than that of males, whilst functional studies have shown that the subcallosal anterior cingulate activates more frequently in female participants than in male participants in emotional valence responsiveness research (Wager et al., 2003). As the cingulate cortex forms an integral part of the limbic system, the system responsible for the processing of emotional information, this may form part of the underlying reason why females are more responsive to emotional information than are males (Wager et al., 2003).

It was interesting to find that males and females responded to stimuli at significantly different rates in all three scenarios. The only exceptions to this were the responses to neutral and positive stimuli in the positive mental imagery condition. However, in all cases, females were faster at responding to stimuli than were the male participants. The largest discrepancy between the rates at which female participants and male participants responded to stimuli occurred in the neutral scenario, with the lowest differences in reaction rate being found in the positive scenario. These findings indicated that female participants were more responsive than male participants to all three types of stimuli following the neutral imagery scenario and the negative mental imagery scenario. This in turn supports findings such as those made by Lithari et al. (2009) who state that gender differences exist in how people respond to emotions and emotional stimuli, with females responding to emotional stimuli faster than males. Also consistent with the findings reported by Lithari et al. (2009) was that females are more responsive to threats than males. The results obtained in the current study also indicated that gender differences were greater following the negative mental imagery scenario than after the positive mental imagery scenario. As the negative stimuli used in this study were primarily selected for their relevance to the biological well-being of participants, the negative stimuli contained in the study were threatening to the biological integrity of the participants. Thus, the increased sensitivity of the female participants to negative stimuli after all three types of mental imagery upholds the notion that females are more responsive to threatening stimuli than males, as is claimed by Lithari et al. (2009).

Having reviewed all the results obtained, as well as having made inferences as to the meaning of these results, three things are clear. Firstly, in accordance with the main hypotheses presented in section 2.7 in Chapter 2, it is evident that various types of mental imagery have different effects on various types of emotionally valenced stimuli. In short, engaging in positive mental imagery creates a bias towards faster reactions to positive stimuli, whilst negative mental imagery biases participants towards decreased response times to negatively valenced stimuli. Secondly, it is also apparent that reaction rates to emotionally valenced stimuli after exposure to various types of mental imagery are significantly influenced by age, with younger adults having faster reaction rates and making fewer incorrect categorisations than older adults. Finally, these results also indicate noticeable differences in terms of gender: the number of incorrect categorisations made by males was twice as high as the number of incorrect categorisations made by females. Furthermore, in most of the conditions, females reacted at faster rates than males.

Whilst the results of the data obtained in this study do indicate that engaging in mental imagery creates a cognitive bias which manifests itself as a preference in processing certain stimuli above others, it is vital for the validity of the study to consider whether there are any other possible alternative explanations for this preferential processing. Only one such alternative explanation presents itself: priming. This shall be further discussed in the following section.

5.3 Alternative explanation

In order for a study to be considered internally valid, it is imperative that the observed results are not explainable through rival hypotheses (Cozby, 2005). Thus, consideration must be given to any other possible explanation for the results obtained in this study. In this case, it could be hypothesised that the mental imagery conditions primed the participants, which would have resulted in decreased reaction rates. Lexical priming can be said to occur when the linguistic context preceding a word alters the response to that word (Jones & Estes, 2012). In other words, a word which is related to the preceding context is recognised faster than unrelated words: thus for example, if a participant were to be presented with a list comprising of the words "brown, blue, red, green, purple", then the participant would recognise the word "yellow" faster than he or she would recognise the word "house", due to the latter word being unrelated to the preceding context. As the stimuli words used in this study needed to be categorised, it can be said that participants were asked to make a semantic decision about each stimulus. As is noted by Jones and Estes (2012), semantic decisions require participants to pay closer attention to the stimuli than other priming measures, as participants are required to make inferences which increase the level of activation of the semantic representation of the stimulus. According to priming models, priming may either occur automatically or strategically, and may be either prospective or retrospective (Jones & Estes, 2012). In the case of prospective models, it is assumed that activation of the priming word activates all associated words including the target word, whilst retrospective models postulate that the priming word and the target word are considered simultaneously, with the target word being recognised faster if it is congruent with the priming word (Jones & Estes, 2012). However, it must be noted that this study was not based on priming. Words presented in each of the stimuli lists were not related to the words used in the control conditions; rather each of the conditions was aimed at inducing emotional states which led to the formation of cognitive biases. Furthermore, had the results observed in this study been due to lexical priming, an increase in response rate would have been seen in all three experimental conditions. However, the fact that response rate was only significantly increased in the positive and negative conditions indicate that priming does not present a satisfactory explanation for the results obtained in this study. Moreover, other studies have shown that certain priming effects are, to a large extent, caused by bias (Zeelenberg et al., 2006).

Thus, whilst priming does present an alternative explanation for the observed results, this explanation is weak and unsatisfactory at best, thereby further strengthening the hypothesis that the results obtained in this study were a direct manifestation of an alteration in cognitive bias induced through the use of mental imagery. That having been said, it is still imperative to examine the limitations inherent in the current research.

5.4 <u>Limitations and their implications for future research</u>

Despite the fact that everything possible was done to ensure that this study was as valid and reliable as possible, there are a few limitations which shall now be discussed in the hope that these issues will be addressed in future research. These limitations include the lack of information on the temporal stability of the cognitive bias, the duration of the training sessions, the test-retest reliability of the study, and the inability to determine the underlying neural mechanisms.

Whilst this study has identified the effects of mental imagery on cognitive biases, inferred through changes in reaction rate, there is no information on the temporal stability of such results. In other words, whilst it is clear that engaging in mental imagery does alter a person's response rate to emotionally valenced stimuli, it is not clear how long this cognitive modification will last for, although it can be assumed that with the application of only a single training session, the effects of that training session soon become extinct. It would therefore be recommendable for future researchers to examine the temporal stability of such an induced cognitive bias modification, and perhaps to do research into the efficacy of multiple training sessions before this research could be fully utilised as a therapeutic method. However, recent work in the field of memory consolidation indicates that the emotional content of memories may be altered, albeit within a small window of the formation of the memory (Schiller, Monfils, Raio, Johnson, LeDoux, & Phelps, 2010). Nevertheless, such findings are encouraging insofar as they show that the emotional content attached to certain concepts may be altered. In the context of the current study, this highlights the possibility of using mental imagery as a technique to alter the emotional valence of stimuli.

A related critique of the current study is the duration of the training session. It ought to be noted that the training sessions utilised in this study were of extremely short duration, which may have resulted in the cognitive bias not being as strong as it might have been had the training sessions been longer. It is possible that the results of this study are not as strong as they might have been if each condition had more trials. For example, one study successfully trained participants to have an attentional bias either towards or away from anxiety-provoking stimuli. However, this was only possible after participants underwent a single training session with hundreds of trials (See et al., 2009). Nevertheless, despite this, the results obtained were highly significant, and demonstrate much potential for the future uses of similar interpretational bias retraining. Moreover, as the purpose of this research was primarily exploratory, keeping the training sessions short was acceptable. It is entirely possible that longer training sessions could have resulted in an ever stronger cognitive bias, manifested by an even greater difference in reaction rate in response to mental imagery. Therefore, it is recommendable for future studies interested in developing the therapeutic aspect of the current research to utilise longer interpretational bias retraining sessions, as such biases would be likely to be more robust.

A further critique of the current study concerns the test-retest reliability of the instrument used. As the measure presented in the current study is not a formal measure, the test-retest reliability of this measure is unknown, which in turn means that the validity of the results cannot be fully ascertained. In a meta-analysis of attentional bias research, Cisler et al. (2009) report that the test-retest reliability of bias scores varies considerably from one instrument to another: more specifically, bias research using the Stroop task had lower test-retest reliability than did research conducted using the dot probe tasks. This conflict in test-retest reliability may be due to the fact that these instruments measure distinct processes. In other words, differences in test-retest reliability may arise because the Stroop test requires inhibition of responses, whilst the dot probe task necessitates attention to be allocated to certain stimuli (Cisler et al., 2009). Thus, it is recommended that future research be done to determine the test-retest reliability of the current measurement instrument. In addition to this, the confidence in the obtained results could have increased had the analysis been done using statistical analysis software specifically designed to run tests such as 3-way ANOVAs or Levene's tests.

Finally, one ought to also bear in mind that as the current study focused on response rates, it is only possible to ascertain whether or not a phenomenon took place. Again, as this research was exploratory in nature, this is an acceptable limitation, as it is important to first establish that a phenomenon does indeed exist before efforts are made into understanding the exact mechanisms underlying the phenomenon. As this current study only utilised response rates from which to infer the conclusions, it was impossible to uncover the exact mechanisms which resulted in the observed phenomenon. In other words, whilst the results of this study showed that mental imagery induced a cognitive bias towards certain stimuli, it could not pinpoint how this induction of a bias occurred. However, as this research established that mental imagery can indeed induce a cognitive bias, it is up to future research to elucidate how this phenomenon occurs.

In short, although this study had several limitations, these limitations were acceptable for an exploratory research study, with the majority of the limitations representing topics beyond the scope of this study. Having established what the limitations of the current research were, it is time to discuss what contributions were made to the field of CBM research.

5.5 Contributions and their implications for future research

The contributions of this research to psychological knowledge are two-fold: namely, the current study has both theoretical and practical implications which shall each be separately explored below.

5.5.1 Theoretical implications

The results of the current research, when taken together with existing research, have provided empirical justification for the hypothesis that mental imagery can be used in the modification of cognitive biases in non-clinical populations.

Through the use of a non-clinical sample, the results of this study were more externally valid than those of previous studies in the field of CBM, as they may be generalised to a much wider population. Because claims of causality cannot be inferred when using a clinical population due to the possible confounding factors inherent in such a population, and as this study conducted research on a non-clinical population, this has provided vital knowledge which can now be generalised to a larger proportion of the general population. Thus, one of the primary contributions of this study was the provision of evidence which was lacking in research which used clinical samples.

A further theoretical implication of this study concerns models on how emotional disorders arise. This study has shown that engaging in negative mental imagery does indeed create a cognitive bias which biases participants to responding to negative stimuli faster than positive stimuli. If this is considered together with previous findings which suggest that negative biases play a role in the development of multiple emotional disorders (Holmes et al., 2007; Bar-Haim, 2010; MacLeod et al., 2009), then the results of this study go some way in not only helping to clarify why emotional disorders develop, but also may inform theories on what risk factors are inherent in the development of emotional disorders. In other words, as this study shows that negative mental imagery leads to negative cognitive biases, and as previous research shows that negative cognitive biases play a role in the development and maintenance of emotional disorders (Holmes et al., 2007; Bar-Haim, 2010; MacLeod et al., 2009), then it can be assumed that negative mental imagery could be one of the factors which contribute to the development and maintenance of several emotional disorders. This in turn has important implications for models of emotional disorder development, and this study illustrates that the presence of negative mental imagery ought to be considered when examining such models.

In addition to these theoretical contributions, the current research also has several important implications for future clinical research. These contributions will be explored in the following subsection.

5.5.2 Clinical implications

Recent studies indicate that as many as one in five people will be diagnosed with depression (Levens & Gotlib, 2010), making depression the most prevalent mood disorder. It is therefore vital to not only find ways of identifying individuals at risk, but also to increase the efficacy of current treatment methods where possible, as well as to find ways of preventing a relapse in those at risk of reverting to maladaptive thinking patterns. Studies have shown that the presence of a negative intrusive imagery in a non-clinical population is correlated with the risk of future diagnosis of depression, whilst the absence of positive mental imagery has been found to play a role in the maintenance of depression (Holmes et al., 2009). These findings, when taken together with those obtained in the current study, suggest that future studies may be able to develop a measure which identifies those at risk of depression through their reaction time to emotionally valenced stimuli after having engaged in mental imagery. Similarly, positive mental imagery training may, with further development, be used in the therapeutic treatment of depression, whilst a measure modelled around the findings of the current study could be used to quantitatively keep track of the progress which patients make. This in turn suggests that the results of this research have a wide range of implications for various clinical applications, which will now be further discussed.

Although this research was theoretical, the findings could have important practical uses. Due to the success of recent CBM-I studies, researchers are beginning to uncover how clinical disorders are formed and maintained, and are also making progress towards being able to use cognitive biases as a treatment for such disorders (Holmes et al., 2009). The findings of this study are distinctive in that the results were drawn from a non-clinical population. These results are therefore also indicative of the potential contributions this study has to offer clinical populations in terms of increased psychological well-being. As is pointed out by Holmes, Mathews, Dalgleish, and Mackintosh (2006), the experimental modification of cognitive biases has shown much promise in the possibility of creating new treatment methods for emotional disorders. Most noticeably, the current research has important potential applications in therapy and counselling, especially in the treatment of emotional disorders. In the case of the potential of the findings in therapy, Lang et al. (2012) indicate that biases are prevalent in many emotional disorders, even though the exact mechanisms vary from one disorder to another. Therefore, a better understanding of the normative role of cognitive biases and their effects on reaction time to emotional stimuli could increase the effectiveness of therapy methods. Thus, one of the primary clinical implications of the results found in this research indicated that negative mental imagery leads to negative biases, whilst positive mental imagery results in positive cognitive biases. This in turn indicates that therapeutic attempts ought to be made in preventing negative mental imagery whilst simultaneously promoting the use of positive mental imagery.

A further contribution made by this study was to address the dearth of normative research. As much of the research conducted in the field of CBM has been done on interpretation biases and cognitive biases in clinical populations, normative research is lacking. Although clinical trials are vital in the understanding and treatment of clinical disorders, this lack of normative research still represents a limitation of the potential scope of the research. For example, such research could have important implications in increasing the quality of life in a normative population, or in dealing with non-clinical negative affect. Thus, the results of this study can be seen as a first step in examining cognitive biases in a normative sample. Moreover, the results of this study provide a foundation on which to base future research which could examine the presence of cognitive biases in order to aid in the identification of people at risk of developing emotional disorders or may even be used to help in prevention efforts in those at risk. For example, as a negative cognitive bias in a person's cognitive style contributes to a higher risk of developing clinical depression (Lang et al., 2012), the results of the current study can be used to create a measure of the extent of a person's negative bias. With further research, this can be developed into a measure of the degree to which a person is at risk of developing clinical depression on the basis of the severity of their negative cognitive bias.

Furthermore, this study has demonstrated that a positive cognitive bias can be induced through the use of positive mental imagery, and it is hoped that future research may be able to transform this finding into a viable therapeutic method. Also importantly, See et al. (2009) report that daily exposure to cognitive bias modification procedures can have a lasting effect on how stimuli are interpreted which persists after such exposure is discontinued, which strengthens the suggestion that the results of this study do indeed hold therapeutic potential. In addition to this, even though the current sample stemmed from a non-clinical population, the results of this study are also applicable to clinical populations because of their therapeutic potential, both as a standalone therapy and as an addition to an existing therapeutic regime. As this study did indeed show that mental imagery causes cognitive biases, it is possible that people with emotional disorders could be taught to interpret everyday events in a more positive manner, which in turn could lessen their emotional distress and thereby increase their quality of life. Whilst therapy in which people are told to try look at life more positively (for example by employing the Socratic method of questioning to examine the truth of their beliefs) has met with some success (Hoppitt et al., 2010), the use of mental imagery to induce a positive cognitive bias could yield far more significant results.

By establishing a positive cognitive bias, one may even establish a virtuous cycle in which positive mental imagery leads to a more positive outlook, which may facilitate more effective positive mental imagery, which further strengthens the positive cognitive bias, which may in turn result in an even more positive outlook. More impressively, such a situation would ideally be possible with only a minimal amount of therapist involvement: beyond a basic training in mental imagery practices, a person suffering from or at risk of depression would be able to completely regulate their own therapeutic regimes according to their own personal needs. Some findings even suggest that a remote delivery of related therapeutic methods, for example via the Internet, has comparable efficacy to therapist-delivered interventions (MacLeod et al., 2009), thereby further increasing the credibility of such a potential therapeutic method. Furthermore, whilst such a therapy may not work in severe cases of depression, such a method may be useful in the prevention of reoccurrences of depression, making a relapse into the use of old, maladaptive cognitive biases less likely.

It is also hoped that the results of this study can be used to help people foster resilience. Resilience can be described as the capability to manage negative events through the use of positive emotions (Levens & Gotlib, 2010). Findings have indicated that the contents of working memory can affect a person's mood, with some researchers suggesting that maladaptive emotional updating of working memory may play a role in the development and maintenance of some emotional disorders such as depression (Levens & Gotlib, 2010). As suggested by Levens and Gotlieb (2010), keeping negative representations active in working memory may increase the risk of developing depression, whilst an increase in the activation of positive representations in working memory may increase the resilience of the person. This suggests that using positive mental imagery to increase the activation of positive representations could increase psychological well-being, and may help protect people at risk from emotional disorders. In light of the observations made in this study, this seems to suggest that mental imagery can be used to avoid keeping negative representations active, as well as increasing the number of positive representations active, thereby simultaneously decreasing the risk of depression whilst increasing the resilience to depression.

However, if the findings made in the current research are to be used in the development of a therapeutic method, there are some weaknesses which ought to be kept in mind. One such downside would be the willingness of the person to engage in the mental imagery. Whilst being able to identify potentially threatening stimuli faster is adaptive in that it helps a person prepare for or cope with danger, it is uncertain why maladaptive and excessive anxiety is so persistent (Hirsch et al., 2009). Hirsch et al. (2009) noted that those who suffer from excessive worries may have little motivation to change their status quo, due to their endorsement of the positive effects of higher anxiety. For example, some patients with Generalised Anxiety Disorder claim that high levels of anxiety are beneficial in that they facilitate problem solving through excessive worrying until the problem is solved (Hirsch et al., 2009). Thus, although this study illustrates the potential application of mental imagery in a therapeutic setting, one must bear in mind that some participants may be unwilling to fully engage in mental imagery due to their beliefs that some aspects of a particular disorder may be beneficial. Additionally, due to the self-delivery nature, such a potential therapeutic method would only work if the person actively engages in it. Due to the decreased therapist intervention, some people could struggle with getting into the routine of utilising mental imagery.

In summary, the results of this study have numerous important and fascinating implications, particularly for the field of emotional disorders and their treatment. However, as this research was an exploratory first step, it is hoped that future research may realise some of the potential applications hinted at in this study.

5.6 Conclusion

To date, research into CBM has been limited, considering the potential applications it has to offer. There has been little to no research on the use of both positive and negative mental imagery to alter existing biases; the current experiment was therefore an important first step in examining how positive and negative mental imagery can be combined with existing CBM techniques, the results of which were very encouraging.

The findings of the current study support the notion that mental imagery can successfully be used to alter cognitive biases, with negative mental imagery evoking a negative bias, and positive mental imagery inducing a positive cognitive bias. These findings have numerous implications for the field of emotional disorders, from informing existing models on how negative mental imagery can lead to negative cognitive biases which can play a role in the development of depression, to providing a basis for potential new therapeutic measures which could possibly be used to treat, prevent, or diagnose emotional disorders such as depression.

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Appendix 1: List of negative stimuli used, including valence and arousal scores

The following negative stimuli were presented in a randomised order by the computer program, with five of these stimuli being presented after each of the mental imagery conditions. Below are the valence and arousal scores for each of the stimuli, as found in the ANEW list (Bradley & Lang, 2010).

	Valence	**Arousal**
1. Abuse	1.80	6.83
2. Death	1.61	4.59
3. Suffocate	1.56	6.03
4. Agony	2.42	6.06
5. Disaster	1.73	6.33
6. Torture	1.56	6.10
7. Infection	1.66	5.03
8. Depression	1.85	4.54
9. Poison	1.98	6.05
10. Betray	1.68	7.24
11. Suicide	1.25	5.73
12. Cancer	1.50	6.42
13. Hurt	1.90	5.85
14. Funeral	1.39	4.94
15. Terrorist	1.69	7.27

In the initial training phase of the computer program, the neutral stimulus "paralysis" was used, with a valence of 1.98, and an arousal value of 4.73 (Bradley & Lang, 2010).

Appendix 2: List of positive stimuli used, including valence and arousal scores

The following positive stimuli were presented in a randomised order by the computer program, with five of these stimuli being presented after each of the mental imagery conditions. Below are the valence and arousal scores for each of the stimuli, as found in the ANEW list (Bradley & Lang, 2010).

	Valence	**Arousal**
1. Free	8.26	5.15
2. Life	7.27	6.02
3. Delight	8.26	5.44
4. Pleasure	8.28	5.74
5. Kiss	8.26	7.32
6. Cash	8.37	7.37
7. Love	8.72	6.44
8. Happy	8.21	6.49
9. Baby	8.22	5.53
10. Triumphant	8.82	6.78
11. Champion	8.44	5.85
12. Joy	8.60	7.22
13. Victory	8.32	6.63
14. Affection	8.39	6.21
15. Passion	8.03	7.26

In the initial training phase of the computer program, the neutral stimulus “Hug” was used, with a valence of 8.00, and an arousal value of 5.35 (Bradley & Lang, 2010).

Appendix 3: List of neutral stimuli used, including valence and arousal scores

The following neutral stimuli were presented in a randomised order by the computer program, with five of these stimuli being presented after each of the mental imagery conditions. Below are the valence and arousal scores for each of the stimuli, as found in the ANEW list (Bradley & Lang, 2010).

	Valence	**Arousal**
1. Pencil	5.22	3.14
2. Barrel	5.05	3.63
3. Square	4.74	3.18
4. Contents	4.89	4.32
5. Umbrella	5.16	3.68
6. Knot	4.75	4.07
7. News	5.30	5.17
8. Table	5.22	2.92
9. Bench	4.61	3.59
10. Statue	5.17	3.46
11. Paper	5.20	2.50
12. Rain	5.08	3.65
13. Bus	4.51	3.55
14. Curtains	4.83	3.62
15. Poster	5.34	3.93

In the initial training phase of the computer program, the neutral stimulus “Street” was used, with a valence of 5.22, and an arousal value of 3.39 (Bradley & Lang, 2010).

Appendix 4: Control and experimental mental imagery conditions used

Control condition: Neutral imagery:

Imagine yourself having an ordinary, average day, just like many other days you have had before. You are walking on the pavement next to a familiar road during the afternoon. It is fairly busy, and there are several people about. There are quite a few cars driving past, but the traffic is light. A gust of wind blows down the street, making the leaves on the trees rustle. You know this route well, so you barely notice the buildings next to you as you walk by. You suddenly hear a car hoot, and you turn around to look, to find out why the car hooted, but nothing is out of the ordinary. You turn back around and carry on with your walk.

Experimental condition 1: Positive imagery:

Imagine that it is a bright sunny weekend, and you are in a very good mood. The weather is perfect, neither too hot nor too cold, but just how you like it. Everything is looking up, and you have a big smile on your face. You have no obligations, and can do whatever you like this weekend. You feel eager and excited for a wonderful, fun break. You put on the radio, and your favourite band is playing. Imagine yourself feeling happy, relaxed and content with life. You sit down to plan your weekend, thinking about all the other great weekends you've had with your loved-ones. You can feel that you're going to have a great weekend filled with cheerfulness.

Experimental condition 2: Negative Imagery:

Imagine that you have had a very bad day. You are fighting with a loved-one, who is blaming you for something you did not do, and you feel hurt and disappointed that they do not believe you. The fight does not go well, and you end up being asked to leave. As you walk to your car, you get very cold. Picture yourself freezing as you run to your car. When you finally get to the car, you get in, shivering and thinking about the argument. Envision yourself putting the key in the ignition, but the car won't start. You know you will probably have to spend a lot of money getting your car fixed. You are cold and miserable, and have a lot of problems.

Appendix 5: Age-related average reaction rates

Age Group		Neutral Stimuli	Positive Stimuli	Negative Stimuli
18-19	**Neutral Scenario**	1350	1355	1272
	Positive Scenario	1241	1110	1296
	Negative Scenario	1213	1348	1432
20-29	**Neutral Scenario**	1502	1473	1508
	Positive Scenario	1486	1341	1494
	Negative Scenario	1506	1489	1406
30-39	**Neutral Scenario**	1374	1452	1466
	Positive Scenario	1524	1612	1394
	Negative Scenario	1318	1404	1361
40-49	**Neutral Scenario**	1655	1684	1890
	Positive Scenario	1570	1477	1597
	Negative Scenario	1531	1522	1417
50-59	**Neutral Scenario**	1336	1574	1497
	Positive Scenario	1247	1324	1373
	Negative Scenario	1393	1440	1338
60-69	**Neutral Scenario**	2372	1906	2115
	Positive Scenario	2034	1566	1624
	Negative Scenario	1876	1935	1581

Appendix 6: Factorial ANOVA results

Anova: Two factor analysis of variance with replication						
SUMMARY	**Neutral Stimuli**	**Positive Stimuli**	**Negative Stimuli**	**Total**		
Neutral Scenario						
Count	400	400	400	1200		
Sum	610780	605626	621221	1837627		
Average	1526.95	1514.065	1553.0525	1531.355833		
Variation	259147.6416	173813.6449	203975.9647	212221.5305		
Positive Scenario						
Count	400	400	400	1200		
Sum	602945	565313	592732	1760990		
Average	1507.3625	1413.2825	1481.83	1467.491667		
Variation	252299.5199	253070.6393	186368.5224	231774.2251		
Negative Scenario						
Count	400	400	400	1200		
Sum	588877	596597	563329.3333	1748803.333		
Average	1472.1925	1491.4925	1408.323333	1457.336111		
Variation	244568.9629	168539.0024	326957.8963	247541.3913		
Total						
Count	1200	1200	1200			
Sum	1802602	1767536	1777282.333			
Average	1502.168333	1472.946667	1481.068611			
Variation	252098.6639	200009.7436	242196.2511			
ANOVA						
Source of Variation	***SS***	***df***	***MS***	***F***	***P-value***	***F-Crit***
Sample	3864274.548	2	1932137.274	8.405706074	0.000228017	2.998232804
Columns	546028.0249	2	273014.0124	1.187739388	0.305029523	2.998232804
Interaction	3179035.22	4	794758.8049	3.457574678	0.007935206	2.374406598
Error	825427975.9	3591	229860.1994			
Total	833017313.7	3599				

Appendix 7: LSD Group Mean Differences

As the critical value for Fisher's LSD was calculated to be 55.77, any mean difference between groups larger than this critical value indicates a significant effect. Group differences for the various scenarios are given in the tables below, and any value exceeding the critical value is indicated by the light grey shading of the relevant cell.

Neutral Scenario		**Neutral Stimuli**	**Positive Stimuli**	**Negative Stimuli**
	Mean	1526.95	1514.07	1553.05
Neutral Stimuli	1526.95	_		
Positive Stimuli	1514.07	12.88	_	
Negative Stimuli	1553.05	-26.10	-38.98	_

Positive Scenario		**Neutral Stimuli**	**Positive Stimuli**	**Negative Stimuli**
	Mean	1507.36	1413.28	1481.83
Neutral Stimuli	1507.36	_		
Positive Stimuli	1413.28	94.08	_	
Negative Stimuli	1481.83	25.53	-68.55	_

Negative Scenario		**Neutral Stimuli**	**Positive Stimuli**	**Negative Stimuli**
	Mean	1472.19	1491.49	1408.32
Neutral Stimuli	1472.19	_		
Positive Stimuli	1491.49	-19.3	_	
Negative Stimuli	1408.32	63.87	83.17	_