Cognitive mechanisms underlying emotion regulation

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The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Traditional theories of emotion have emphasised the automatic and unconscious nature of emotion generation and hence emotion regulation via antecedent and response focused strategies. Response strategies either inhibit the expression of an emotional response or modulate it via cognitive reappraisal. Antecedent strategies involve avoidance behaviour i.e. avoiding situations in which the emotional response is likely to occur. Recent evidence has now demonstrated, however, that the cognitive and emotional systems are highly interactive and that *conscious attention* may be necessary to generate emotion. Conscious attention can be controlled via executive functioning and the requirements of immediate goals. This evidence opens up the possibility of regulating emotions by executive functioning *on-line* i.e. as they occur.

The aim of this thesis was to investigate on-going emotion generation and the mechanisms and processes that regulate it. A series of experiments manipulated cognitive functioning via direct instructions to Feel and Not Feel emotional responses to negative and neutral pictures and, indirectly, by manipulating cognitive resources available for processing the pictures. Participants in the latter experiments were required to maintain visual attention to the stimuli in order to rate the strength of their emotional responses to them whilst simultaneously holding in mind pictures or words requiring a subsequent same-different decision to a following item. It was believed that depleting cognitive resources could attenuate emotional responses.

Results from the experiments showed that emotional responses can be attenuated by depleting *cognitive resources* available for processing emotional

stimuli; an explanation that can explain both direct and indirect manipulations of cognitive functioning. It was not clear, however, whether emotion generation is not automatic or whether automatic processing requires some input from cognitive resources. Further research is also required to discover whether the cognitive resources required to generate emotions involve executive functioning for visual attentional processing, to maintain conscious attention for higher order processing, or for low level cognitive appraisals.

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Abbreviations

ACC	- Anterior cingulate cortex
CBR	- Cerebral blood flow
CSEA_NIMH	- NIMH Center for the Study of Emotion and Attention
DLPFC	- Dorsolateral prefrontal cortex
EEG	- Electroencephalography
EMG	- Electromyography
ERP	- Evoked response potential
fMRI	- functional magnetic resonance imaging
GSR	- Galvanic skin response
HR	- Heart rate
IAPs	- International Affective Picture System
IDA	- Intelligent Distribution Agent
IFG	- Inferior frontal gyrus
LTP	- Long term potentiation
LMPFC	- Lateral medial prefrontal cortex
MOFC	- Medial orbital frontal cortex
MPFC	- Medial prefrontal cortex
NMDA	- N-methyl *D* – aspartate
PET	- Positron emission tomography
PFC	- Prefrontal cortex
SCR	- Skin conductance response
STS	- Superior temporal sulcus

Preface

Introduction

Emotion is a change in affective state that accompanies a change in perception. It may be experienced as positive or negative feelings (emotions) and may be expressed in behaviour.

According to James Gross most researchers agree that emotion is a complex multicomponential concept consisting of a physiological, experiential and behavioural component (Gross, 1999a). Current definitions of emotion are prolific because most tend to focus on the component of particular interest to the researcher. The definition above is an attempt to incorporate all the components of an emotion into one definition without losing specificity. Essentially, the definition is part of a communication model of society in which individuals and social groups are believed to construct their own understandings of the world around them and live their lives within their shared realities. Within this model, perceptions of reality are understood to be cognitively constructed via unconscious processes in the brain, and feelings function to signal changes in perception to both the individual and interacting others. Communication of feelings is essential for empathic processing and human understanding of each other. It is also a useful predictor of behaviour. The model has its roots in evolution and Charles Darwin's work, 'The Expression of the Emotions in Man and Animals' (Darwin, 1872). Discourse analysts have done much to update it.

The definition above, makes an important distinction between emotion (i.e. an uncountable state) and emotions (countable feelings). Emotions are easy to define as readily understandable feelings such as fear and sadness. Emotion, however, is more complex. The following analogy based on Eleanor Rosch's work on concept formation (Rosch *et al.*, 1976), is an attempt to explain how it is used in the definition above.

In object recognition, when we see a dog barking and wagging its tail, we don't focus on the head *or* the bark *or* the tail in order to recognize it as a dog. A dog's head on a giraffe's body would not be sufficient to label the animal 'dog'. Neither would a dog's head issuing monkey chatter. Though perhaps not all equally important, features consistent with a dog (e.g. head, tail and bark) are all necessary features. An emotion can be understood in a similar way. Perception of a knife without the hand that holds it, or the hate in the eyes of the aggressor, or the feelings of fear, helplessness or anger that the perception generates, is just a knife. The knife together with the contextual information and the meaning constructed from it, produces a change in perceived reality and a general change in affective state: in this case, a change from a general sense of well-being to one of insecurity. It is this change that defines the word emotion above.

In the modern world, it is not always safe or advantageous to express emotions and signal changes in affective state. In a given situation, expressed fear may change perceptions of the balance of power and control, and a potential survivor of an assault may become a victim. Too much expressed care and concern for a child may suffocate rather than strengthen family bonds. Emotion regulation is hugely influential in the management of social relationships, and perceptions of how it works underpins social interactions at the level of the individual and society. Legal, political and social policies and practices are underpinned by knowledge of how emotion works e.g crimes of passion and leniency versus rational, predetermined action and zero tolerance. It is essential, therefore, that research continues to try and elucidate the mechanisms and processes that underpin emotion regulation.

In this thesis, references to emotion, emotions and emotion regulation attempt to reflect the definitions specific to the perspectives and research discussed. However, the understanding that guides and drives the thesis itself is the understanding of emotion embedded in the definition above and explained in the analogy. The rationale for the focus of the thesis is the importance of emotion regulation in social interaction, and the specific interest, the way in which biological constraints may facilitate or constrain success.

Broadly speaking, the thesis itself is a record of a journey from a common sense understanding of emotion to an empirically tested, and testable, scientific discourse. It is divided into three parts. Part 1 provides a grounding for later work by briefly summarising existing research and methodologies and informing early experimental designs, design issues and initial explorative experiments. Part 2 focuses specifically on distraction as a method of regulating emotions and, using the n-back and startle paradigms, tries to identify the mechanisms and processes that underlie it. Part 3 brings together the evidence into a single, eclectic scientific discourse that may have implications for cognitive appraisal theory and a potential understanding of situational factors that may affect PTSD. The thesis concludes with suggestions for further research required to validate the findings

Part I

Conscious and Intentional Control

Chapter 1

Emotion Generation Mechanisms and Regulation Strategies

1.1. Emotion Generation Mechanisms

1.1.1. Cortical and sub-cortical pathways

Elucidation of the neural pathways involved in fear conditioning by Joseph LeDoux and colleagues has been fundamental to all emotion research. The identification of two major pathways involved in the registration and storage of an emotional stimulus and in the generation of a response (i.e. the thalamo-amygdala and cortico-amygdala pathways), underpins all research on emotion generation and regulation (see Figure 1).

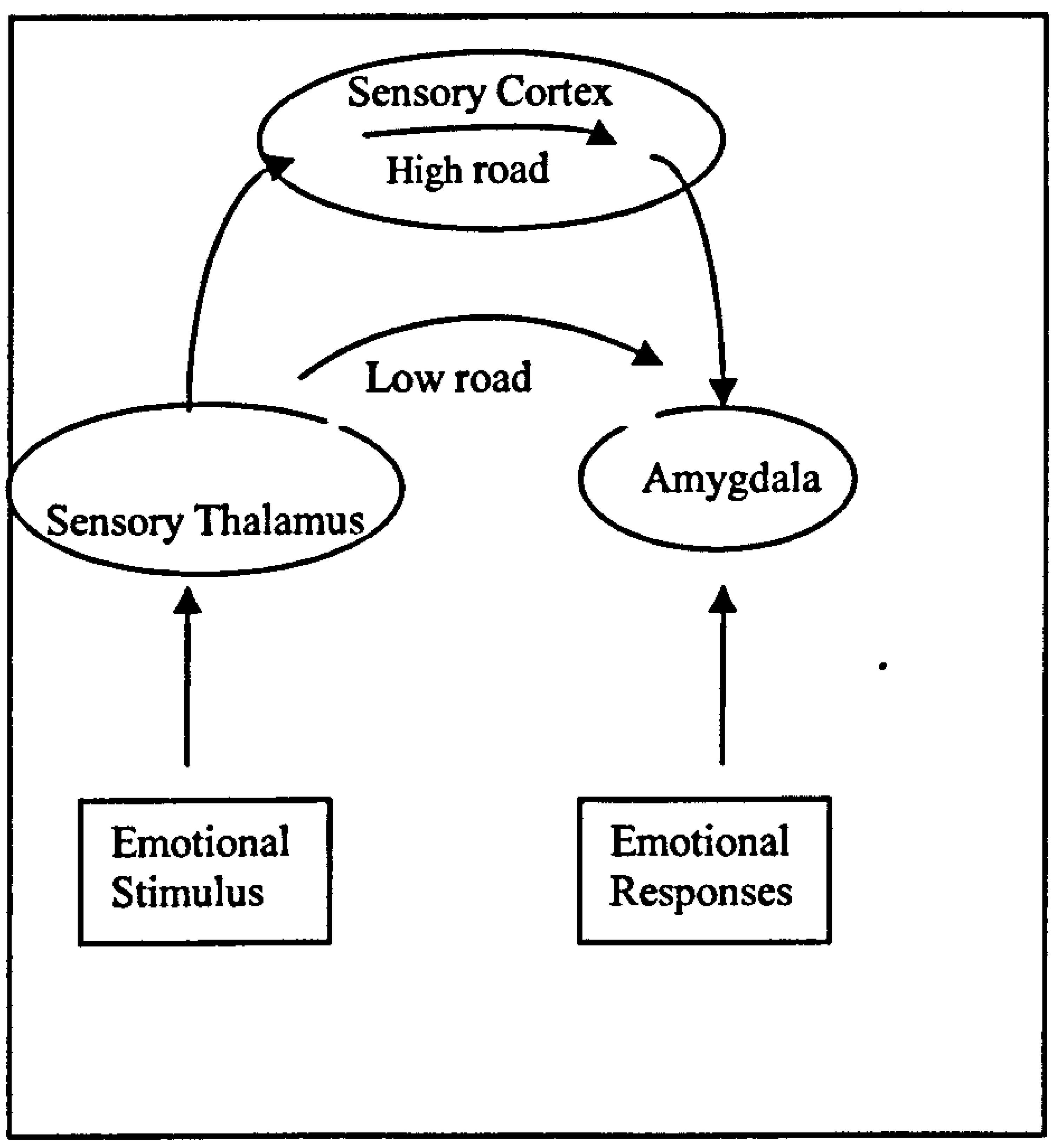


Figure 1: The High and the Low Roads to the Amygdala (LeDoux, 1996)

The thalamo-amygdala pathway, the route that directly connects the sensory thalamus to the lateral nucleus of the amygdala, is believed by many to be the route by which emotions are unconsciously and automatically generated. Visual and auditory cells in the sensory thalamus that respond to very basic physical features of sound and vision, produce fast, though crude, information about the external environment that bypasses cortical networks and thus generates immediate physiological and behavioural responses. Signals from the sensory thalamus are transmitted to the central nucleus of the amygdala and thence to other amygdala nuclei to produce appropriate responses (see Figure 2). Signals to the central gray, for example, induce freezing behaviour, to the lateral hypothalamus, change heart rate and blood pressure, to the paraventricular hypothalamus, release stress hormones and to the reticulo-pontis caudalis generate the startle reflex. The processes are thought to be fast, unconscious, automatic (LeDoux, 1996) and, when triggered, produce responses that together can be called an emotion.

The cortico-amygdala pathway, on the other hand, is believed to be slower but registers more detailed information and functions to inhibit inappropriate responses rather than to generate appropriate ones. LeDoux believed that co-ordination of the two sets of information appeared to be controlled by the lateral nucleus of the amygdala where the two pathways converge (see Figure 2).

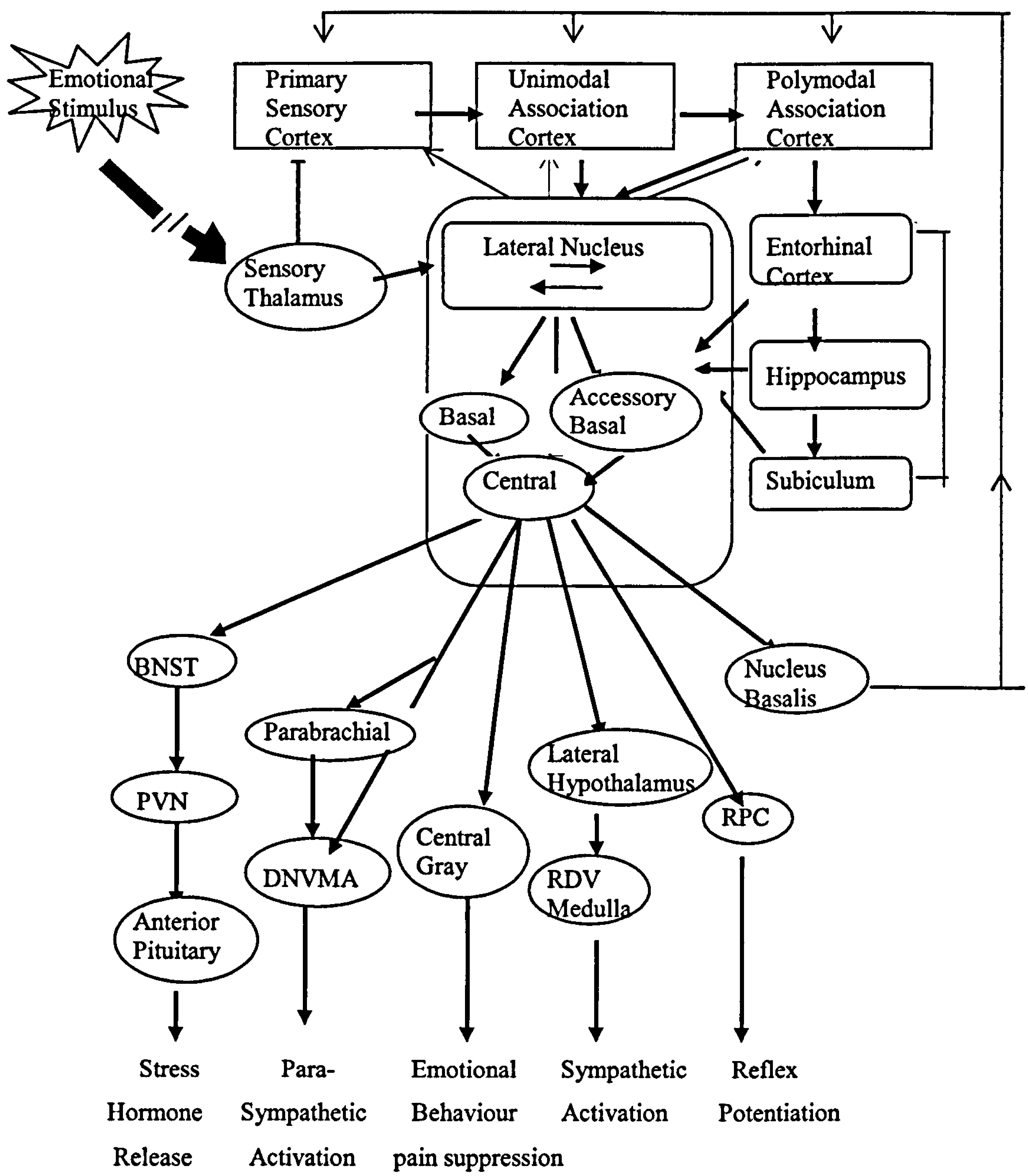


Figure 2: Fear conditioning pathways

BNST: bed nucleus of the stria terminalis ; DMV: dorsal motor nucleus of the vagus; NA: nucleus ambiguus; RPC: nucleus reticularis pontis caudalis; RV Medulla: rostral ventrolateral nuclei of the medulla; PVH: paraventricular nucleus of the hypothalamus. (LeDoux, 1997, p1720)

1.1.2 The amygdala

Though a key mechanism in the emotion generating process, the amygdala is also crucial in the storage of 'emotional memories', in prioritizing information for conscious and unconscious perceptual processing, in biasing resources towards the processing of that information, and, as a result, in influencing the content of explicit memory.

Memory of the emotional stimulus and the generated response is stored as an implicit, non-declarative 'emotional' memory. Implicit memories are outside conscious awareness and, unlike explicit memories, cannot be consciously recalled. LeDoux makes the distinction between 'emotional memories'(i.e. the implicit memory), and 'memory of an emotion' (i.e the explicit memory) (LeDoux, 1996). The implicit memory involves the crude perception of the external stimulus registered by the cells in the thalamus that directly trigger the amygdala and thence physiological and behavioural responses. NMDA (*N*-methyl *D*-aspartate) receptors in the amygdala that bind glutamate from simultaneously firing neurons, producing long term potentiation (LTP i.e.strengthened synapses between neurons) (Malenka and Nicoll, 1999, Maren, 1999), link together small groups of neurons that are triggered automatically by the external stimulus (LeDoux and Muller, 1997). This type of learning and memory was originally referred to as fear conditioning since research primarily concentrated on the registration and storage of fear responses (Lang et al., 2000, LeDoux, 1996, LeDoux and Muller, 1997), but later also became known as classical conditioning. Over time, changes in the cells themselves that make them more sensitive to the conditioned stimuli (LeDoux and Muller, 1997) ensure the hard-wiring of the event in memory. Since hard-wired into neural networks, this type of memory can only be controlled via inhibition (i.e. the control of responses by the prefrontal cortex). The spontaeous recovery of memories after desensitization has occurred is taken as evidence of their endurance and required inhibition to control (LeDoux, 1996).

The explicit memory is more detailed, involves higher order cortical processing, involves the hippocampus in storage processes and can be consciously recalled. Whilst damage to amygdala NMDA receptors disrupts fear conditioning (LeDoux, 1996, Maren, 1999), damage to hippocampal NMDA receptors impairs explicit memories and memory for the context in which fear conditioning occurred (LeDoux, 1996). According to LeDoux, the two memory systems only meet in working memory when current external stimuli activate the thalamo-amygdala pathway and generate the same responses that were triggered at the time of the original event. These responses are then experienced alongside current explicit recall of the memory, forming an impression of past emotion (LeDoux, 1996).

More recent research (Clark *et al.*, 2002) has also identified differences in the conditioning processes that store the two types of memories i.e. delay conditioning and trace conditioning. Delay conditioning that requires the cerebellum and associated brainstem structures but no forebrain structures offers a mechanism for implicit memory construction. Trace conditioning, however, that requires both the hippocampus and the neocortex in addition to the cerebellum and therefore also involves conscious awareness, offers a mechanism for explicit memory construction.

Although emotion and cognition have long been thought of as separate systems functioning in different ways (LeDoux, 1996, Zajonc, 1980), it is the *interaction* of the two rather than their separateness that appears important. For example, recent research has highlighted more general functions for the amygdala such as attentional control (Davis and Whalen, 2001, Phelps, 2004, Phelps, 2006), visual awareness

(Duncan and Barrett, 2007), and the modulation of memories of emotion in the conscious explicit memory system by unconscious amygdala activation (Phelps, 2004, Phelps, 2006).

In a review of animal and human literature investigating the role of the amygdala in fear conditioning, Davis and Whalen cite much research that demonstrates an attention or *orienting reflex* generated by electrical stimulation of the central nucleus in the amygdala (Davis and Whalen, 2001). In humans, pictures of snakes, spiders and angry faces have been shown to capture attention more quickly than neutral stimuli (Öhman *et al.*, 2001) and are believed to be the result of evolutionary hard-wired responses. The increased state of arousal that follows stimulation of the central nucleus in the amygdala is believed to enhance sensory processing. Conscious instruction has also been shown to influence attention. Research by Halgren, (Halgren, 1992 in Davis & Whalen, 2001) has demonstrated that an N200/P300 evoked response that is prominent within the amygdala, for example, is larger when subjects are instructed to attend to a stimulus. By processing a stimulus early (see Figure 3), it is thought that signals from the amygdala could, via feeback connections, enhance later perception and thereby increase perceptual encoding of emotional stimuli (Duncan and Barrett, 2007, Phelps, 2004). Evidence for early and late perceptual processing is well established (Adolphs, 2002, Codispoti et al., 2006, Codispoti et al., 2007) and could support such a function for the amygdala.

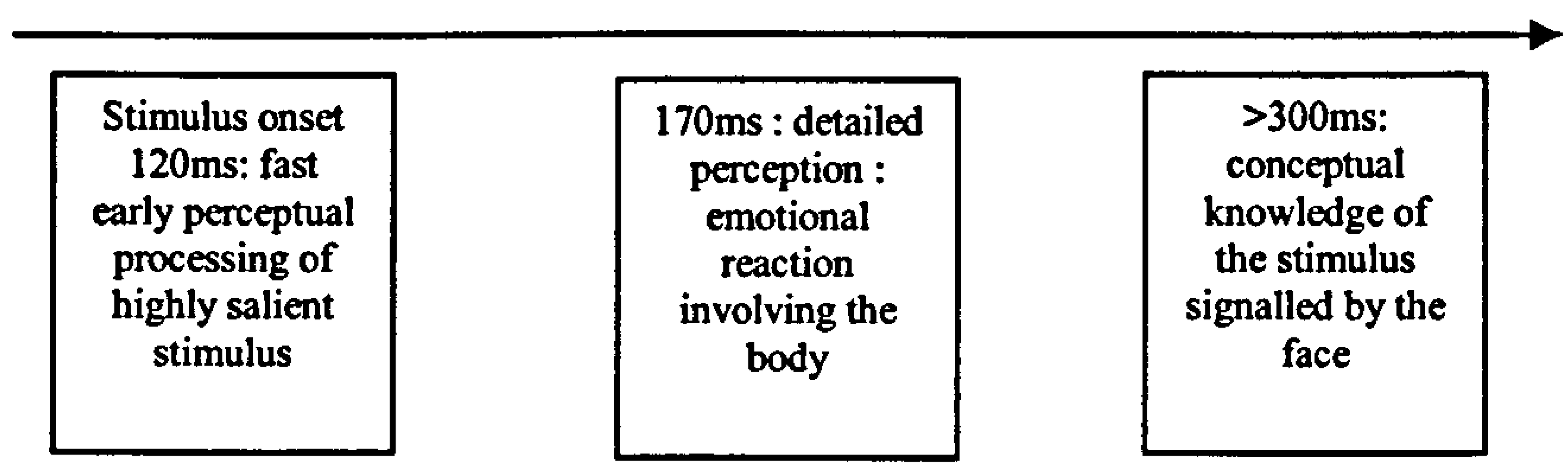


Figure 3: Early and Late perceptual processing (Adolphs, 2002)

The role of the amygdala in visual awareness is much debated but has important implications for emotion generation and regulation. The debate was re-opened recently by Pessoa who claimed that results from experiments manipulating attention (Pessoa et al., 2005a, Pessoa et al., 2005b) suggested that conscious awareness was necessary for the activation of the amygdala. However, in a reply to the claim, Duncan and Barrett maintain that amygdala involvement in perceptual processing is well documented and that conscious awareness may be the *result* of amygdala activity rather than a requirement for amygdala activation i.e. the amygdala's enhancement of perceptual processing could help generate conscious awareness though may not always do so (Duncan and Barrett, 2007). Though further research is necessary to resolve the issue, the role of the amygdala in the processing of stimuli in the ventral visual stream is evidence of at least some mechanisms that are shared by both cognitive and emotional systems.

The interaction of the amygdala with hippocampal dependent explicit memories appears to occur during both the encoding and storage stages of information processing. By enhancing perception and attention, the amygdala increases the likelihood of the encoding of the attended stimulus, and by releasing stress hormones such as adrenaline, it can modulate the consolidation of such stimuli in memory (Phelps, 2004, Cahill and Alkire, 2003). In this way, the *interaction* of the cognitive and emotion systems, once again, influences experiences of both 'memories of emotion' and future experiences.

1.1.3. The neocortex

Although many psychologists accept the evolutionary model of emotion generation implicit in the description of emotion mechanisms outlined above, many do not. In the 1960s and 1980s, in particular, psychologists such as Richard Lazarus, Nico Frijda, Magda Arnold and the social constructivists argued vehemently in favour of a cognitive approach (Arnold, 1960, Frijda, 2004, Lazarus, 1982). Though some acknowledged a dual process in which fast, unconscious, low level appraisals may precede slower, more detailed, higher level reflective ones involving evaluation and interpretation processes (Arnold, 1960, Kappas, 2006), many maintained that cognitive appraisals of situations and events *must* precede emotion generation with the constructed *meaning* for the individual giving rise to the emotion itself.

A description of the cortical regions involved in cognitive appraisal is more difficult, though, since it must virtually describe the entire information processing network, knowledge of which is still limited. A search through the emotion regulation literature, however, reveals much general agreement on some of the cortical regions involved. Using EEG (electroencephalography), fMRI (functional magnetic resonance imaging), and PET (positron emission tomography), for example, researchers have shown that activation of the prefrontal cortex occurs during evaluations of external context (Green and Malhi, 2006) whilst activation of areas in the medial prefrontal cortex (MPFC) occurs during evaluations of self relevance and monitoring of an internal emotional state (Green and Malhi, 2006, Gusnard et al., 2001, Lane et al., 1997). More specific functions of the PFC identified include a general monitoring of the external environment by the lateral prefrontal cortex (LPFC) (D'Esposito *et al.*, 2000), an evaluation of the significance of the context by means of interactions with memory and attentional systems by the PFC and LPFC (Green and Malhi, 2006, Ochsner et al., 2002) and an interpretation of the precise meaning of a stimulus within that context by the medial orbital frontal cortex (MOFC) (Green and Malhi, 2006).

Special areas for face perception have also been identified and involve multiple bilateral regions of the ventral temporal and association cortices. More specifically, facial movement appears to be the concern of the lateral temporal cortex, and the direction of eye gaze and mouth movement the concern of the superior temporal sulcus (STS) (Green and Malhi, 2006). Cortical regions identified in facial expressions of emotion include the insula for disgust (Phillips et al., 1998, Phillips et al., 1997) and the left dorsolateral frontal cortex and right fusiform gyrus for expressions of fear (Sprengelmeyer *et al.*, 1998).

More specific functions of the MPFC appear to involve the means by which self relevance can be evaluated. It is the MPFC, for example, that is believed to monitor internal experiential and physiological responses to external stimuli and to construct interpretations of the mental state and the intentions of others.

Direct connections between the MPFC and the amygdala (Ochsner et al., 2002) suggest an appropriate pathway by which the outcomes of cortical appraisals can activate the amygdala and generate emotional responses.

1.2. Emotion Regulation

> "Emotion regulation refers to the processes by which individuals influence which emotions they have, when they have them, and how they experience and express them. Emotion regulatory processes may be automatic or controlled, conscious or unconscious, and may have their effects at one or more points in the emotion generative process" (Gross, 1998a).

This general definition of emotion regulation by Gross captures the diversity in emotion generation and regulation theories and highlights the importance of both the thalamo-amygdala pathway and the thalamo-cortical pathway in the modulation of emotional responses. According to Gross, most researchers accept a multicomponential description of the emotional process (see Figure 4) even if they disagree on the precise definition of emotion (see Chapter 2) and the source of the emotional trigger. Regulation strategies, therefore, are generally accepted as attempts to modulate activity in one or more components of the emotional process and since the process itself is automatic once generated, fall into two groups: antecedent and response focused.

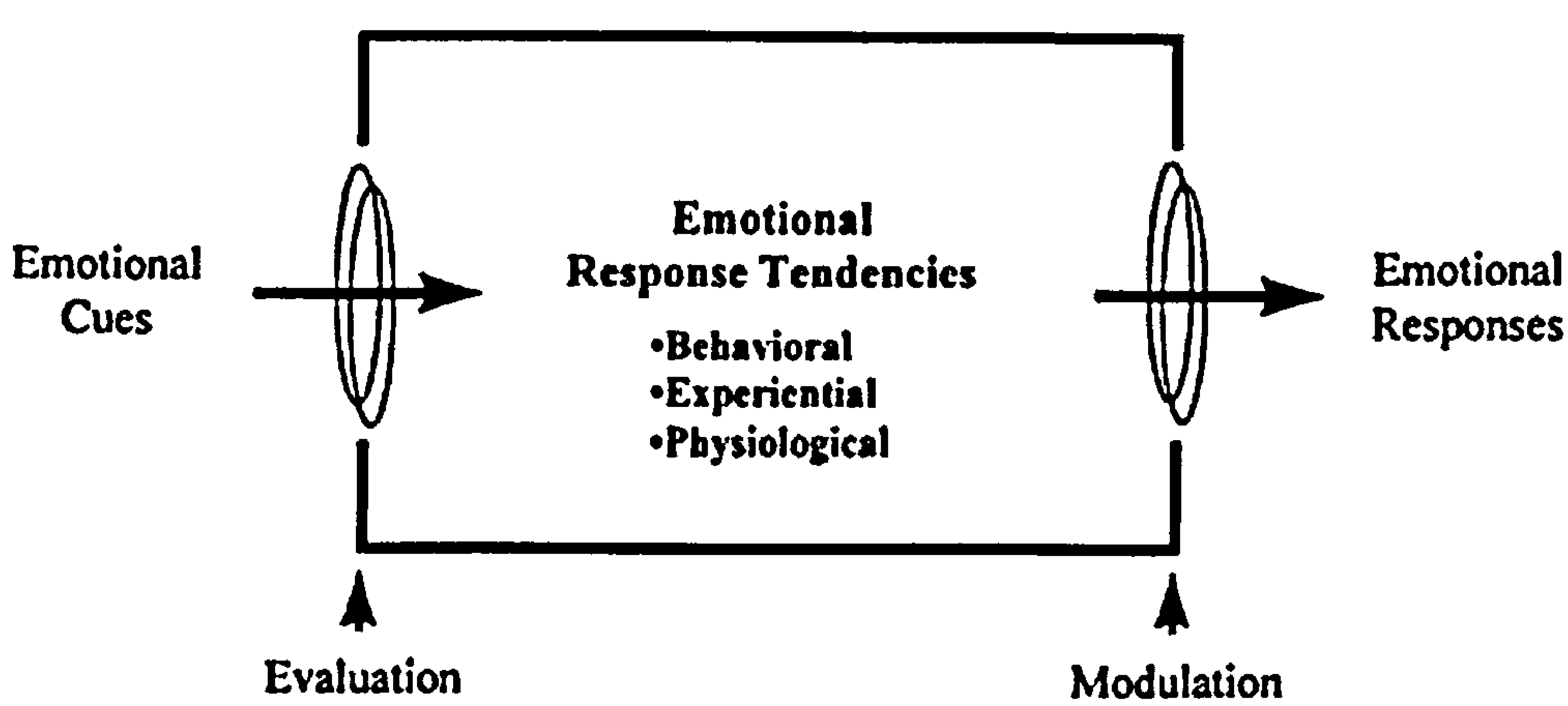


Figure 4: A consensual process model of emotion (Gross, 1998a)

Antecedent strategies tend to be anticipatory strategies, whilst response focused strategies attempt to modulate outcomes. Successful modulation of any one of the components of an emotion (i.e. the physiological, behavioural or experiential component) is believed to result in modulation of the others. Regulation strategies, therefore, focus on one or more of these components and target either anticipatory or post hoc responses. Four major emotion regulation strategies have been investigated by researchers in some depth: suppression, detachment, distraction, and cognitive appraisal. Of the four, suppression is the only one that addresses non-cognitive responses and will be described first.

1.2.1. Suppression

In commonsense discourse, use of the term suppression has been heavily influenced by Freud and is often implicitly defined as the inhibition of emotional feelings. In emotion literature, however, it usually either refers to the inhibition of the *expression* of emotion (Gross, 1998a, Gross, 1999a) involving some cognitive control, or is sometimes used as a synonym for cognitive re-appraisal (Phan *et al.*, 2005). In early studies, it was defined as, "inhibiting emotion-expressive behavior while emotionally aroused" (Gross and Levenson, 1993). Since cognitive appraisal and suppression are very different, cognitive re-appraisal will be described separately.

Some of the earliest studies investigating suppression, however, concentrated on thought suppression rather than behaviour. Wegner's famous 'white bear' experiments, for example, were an attempt to manipulate direct control of thought via an instruction *not* to think of a white bear (Wegner *et al.*, 1987). Unfortunately, Wegner discovered that newly formed associations between distracting items and the unwanted thought provided numerous associated cues to activate the memory at a later date.

Suppression of the expression of emotion has been more successful. Suppression of emotional expression is often conscious and effortful and can involve the modulation of facial expressions, tones of voice and overt action. In all instances, the behavioural response is triggered by the generation of the emotion and suppressed via cortical inhibition executed by the prefrontal and premotor cortex. Evidence for PFC involvement in suppression has been confirmed recently in studies that demonstrated the mediation of sustained changes in the allocation of control processes by the PFC, a transient role for the anterior cingulate cortex (ACC) when additional control is required (Mitchell *et al.*, 2007) and the crucial function of the right inferior frontal gyrus (IFG) for inhibitory control (Chambers *et al.*, 2007).

When physiological responses alone were thought to generate emotion (James, 1884) suppression of motor responses was thought to dampen the emotion automatically. “Refuse to express a passion, and it dies” (James, 1884). However, more recent research suggests that the effort involved in suppressing such responses may, in fact, increase physiological responses such as heart rate (Gross, 1998b, Gross and Levenson, 1997b) and thereby, presumably, the intensity of the emotion. In later studies evidence also suggests that expressive suppression impairs memory (Richards and Gross, 2000, Richards and Gross, 2006). As a strategy for regulating emotion, therefore, suppression would appear to be one of the least successful.

1.2.2. Distraction

Two types of distraction are described in the literature, attentional and cognitive distraction. Attentional distraction is defined as "thoughts and behaviors that take the individual's mind off his or her symptoms of depression and put it onto pleasant or neutral activities" (Nolen-Hoeksema, 1987, 1991). It is a form of attentional bias that is used in an attempt to reduce the experience of negative emotion. By reducing perception of the negative stimulus, experiential, physiological and behavioural responses that may have been activated are avoided. At Arizona State University, results from a study of undergraduates that measured an association between attentional avoidance and cortisol levels found that high anxiety individuals utilized attentional avoidance more often than low anxiety individuals and showed lower cortisol levels during avoidance (Appelhans and Luecken, 2006). The results demonstrate a clear link between perception of a negative stimulus, a physiological response involving cortisol production and a successful emotion regulation strategy involving reduced attention.

Another attentional strategy designed to reduce the experience of high negative arousal is distraction via activity. For young children rocking, sucking and grasping can distract them (Dodge, 1989), whilst for adults physical activity such as walking, bowling and jogging can reduce attention to the negative stimulus (Morrow and Nolen-Hoeksema, 1990). Physical activity has been shown to counter depression by increasing positive mood (Berger and Motl, 2000) but Morrow and Nolen-Hoeksema also claim an effect of distraction. However, they do state that activity distraction is less successful than cognitive distraction because individuals can still ruminate on depressive moods whilst exercising.

Rumination is defined as,

> "thoughts and behaviors that focus the depressed individual's attention on his or her symptoms and the possible causes and consequences of those symptoms" (Nolen-Hoeksema, 1987, 1991).

Rumination is a cognitive distraction strategy that removes attention from the external stimulus but replaces it with an internal focus that is largely unsuccessful since it tends to *increase* the duration and likelihood of negative mood rather than relieve it (Morrow and Nolen-Hoeksema, 1990, Nolen-Hoeksema, 2000, Nolen-Hoeksema et al.). By continually reflecting on negative experiences, a negative mind set may develop that increases the likelihood of interpreting new information negatively, reinforces negative impressions of the self, distracts attention from potentially positive forms of action, and generates a sense of hopelessness (Nolen-Hoeksema, 2000, Nolen-Hoeksema et al.). Cognitive distraction tendencies that are more successful tend to involve *effortful* distraction and the processing of information that is totally unrelated to the emotion generating stimulus, and which, in a limited capacity cognitive system, must replace it.

Effortful cognitive distraction can be used as an antecedent or response focused strategy. It is a strategy that focuses on the generation of emotion via cognitive appraisal rather than automatic biologically determined response tendencies, and thus suggests an explanation of the modulation of emotional experience via the reduction in cognitive resources available to process the stimulus. As stated previously, various cortical regions process different aspects of an external stimulus and have been shown to modulate amygdala activation. Of relevance to cognitive distraction is the role of the LPFC and MPFC in modulating amygdala activity (Ochsner et al., 2002). In the 2002 study, Ochsner et al demonstrated that activation in the ventral LPFC was inversely correlated with activation of the amygdala and the MOFC, suggesting that activating the LPFC will modulate emotion processing. Both regions (i.e. the LPFC and the MPFC), he maintained, are similar to the regions activated during working memory and may well modulate emotion by modulating the amount of cognitive processing of the emotion generating stimulus. In cognitive distraction studies using fMRI, activation of the anterior rostral MPFC, by use of a distracting working memory task, has been shown to 'down regulate' registered negative emotion in both the MPFC and the amygdala (Erk *et al.*, 2006). In a study measuring self reported mood ratings, increasing task difficulty was also found to reduce negative mood ratings (Van Dillen and Koole, 2007). Both studies showed success in modulating *antecedent* responses to emotion generating stimuli.

1.2.3. Detachment

Detachment has been defined as "reappraisal by denial of relevance" (Kalisch *et al.*, 2005). Basically, a situation is appraised as potentially emotional, but the appraiser adopts an objective perspective and denies the relevance of both the situation and the emotion to themselves. Successful detachment can result in attenuated physiological responses to unpleasant stimuli and has been shown to be a common factor in psychopathy (Patrick *et al.*, 1993), although the strategy can be used by normal populations (Kalisch et al., 2005, Osumi et al., 2007). Detachment is also sometimes referred to as disengagement, dissociation and isolation.

1.2.4. Cognitive appraisal

According to Clore and Ortony, *appraisal* refers to the 'assignment of value or emotional meaning' (Clore and Ortony, 2000). Cognitive appraisal describes the emotion regulation strategy that focuses on interpretations and evaluations of stimuli that then modulate the emotion itself. Research by Gross and Ochsner has been particularly useful in highlighting the way in which cognitive appraisals can modulate amygdala activity (Ochsner et al., 2002, Ochsner and Gross, 2005). Basically, it works by changing a negative appraisal to an objective or more neutral interpretation. Appraisal processes that activate the MOFC also modulate activity in the amygdala with negative interpretations producing greater activation than neutral (Ochsner et al., 2002), but reappraisals either enhance or attenuate activity depending on whether they involve changes in meaning from negative to positive, or increased negativity. Of particular interest, was evidence that a conscious instruction to re-appraise a stimulus could affect amygdala activation (Schaefer *et al.*, 2002). This suggests that in addition to affect modulation, affect *generation* may be less automatic than previously thought and may be open to at least some degree of conscious control.

1.3. Aims and objectives of this study

In 1999, Gross highlighted the fact that cognitive, behavioural and pharmacological means could all be used *indirectly* to modify the emotion experience. However, he also maintained that " it is less certain whether emotion experience can be modified directly" (Gross, 1999b). Today, with the evidence of cortical modulation of amygdala activity outlined above, *direct* control may be a possibility. The aim of this study was to test the possibility of direct regulation i.e. the possibility that an individual could control perceptual change and thereby a change in affective state .

Chapter 2
Methodology

1.1. Introduction

"Nothing proceeds from itself. Nothing is given. All is constructed."
Gaston Bachelard (1934)

One of the initial aims of this study was to take an empirical, scientific approach and test the Freudian assumption of suppression that is embedded in common sense discourse and which suggests that feelings can be consciously and intentionally controlled. Though opting for scientific methodology, the aim is not to search for scientific 'truths' but simply to test common sense assumptions about emotion regulation against empirical validity.

Scientific methodology has been attacked for its pursuit of 'truth'. Philosophers question the validity of such pursuits when ontological reality appears to have no meaningful existence outside language and discourse (Bachelard, 1934; Wittgenstein 1953/1967). Social and radical constructivists challenge beliefs in a single, objective reality with beliefs in multiple socially and cognitively constructed discourses that compete for interpretative supremacy (Berger and Luckmann, 1966, von Glasersfeld, 1984). For sociologists of knowledge, scientific 'truth' has been replaced by competing discourses vying for power and control in society (Foucault, 1967, Foucault, 1977). Even for 'soft' scientists, however, discourse must still have empirical validity and though science itself may be a discourse, it may still function to compare, falsify and thus evaluate other discourses. Scientific research still requires a 'descriptively accurate and prescriptively useful methodology' (Lakatos, 1970) capable of testing, falsifying (Popper, 1994) and thereby informing political, legal, social and common sense discourses, policies and practices. Though specific discourses may change with political function, science would still appear to have a role to play in providing a measure of validity that subverts the potential for discursive anarchy.

The problem for emotion researchers attempting to differentiate between discourses or theories that are useful and those that violate tests of validity and reliability, is that technological limitations constrain tests of empirical validity. fMRI and PET scans cannot yet trace activation in specific neurons, or between one neuron and another. The result is a knowledge base that is largely theory dependent, fragmented and piecemeal: a plethora of theories and therapies with theory dependent definitions of key concepts that make comparability, falsification and unification difficult.

Although this study will do little, if anything, to overcome the problem, it is hoped that it will test an assumption that has real effects in everyday social and legal understandings of emotion and corresponding policies and practices.

1.2. Current research: concepts and methodologies

A brief review of current research to identify key concepts and methodologies with which to inform design decisions, reveals little coherence in the knowledge base. With technological limitations constraining empirical power, old ideas and assumptions continue to be influential. Descartes' mind/body dichotomy, for example, still underpins ubiquitous references to 'cognition and emotion' and thus reinforces ideas of separate systems and separate functions i.e. cognition, rationality and the cerebral cortex; emotion, irrationality and the limbic system. Echoes of the James-Canon debate, though long since resolved, linger still in research as diverse as studies of facial expression and the generation of emotion (Ekman, 2004, Oatley, 1992) and cognitive evaluations of the self-relevance of external stimuli and the generation of 'states of action readiness' (Oatley, 1992). However, though a single, comprehensive theory of emotion, as yet, eludes researchers, a brief review of current thinking and practice highlights the importance of clearly defining the research area, constructing precise definitions of key concepts and selecting appropriate methodologies. The following information provides the basis on which such decisions were made for this study.

1.2.1. Definitions of Emotion

Though much research into 'hot cognition' is now rejecting the separation of cognition and emotion, present definitions of emotion are still theory dependent. A slight flavour of the current position is captured by the following question:

"Are emotions to be conceptualized as brain modes, actions or action tendencies, reflexes, instincts, attitudes, cognitive structures, motives, sensations or feelings?" (Russell, 2003).

A brief definition of five of the most commonly used conceptualizations may help clarify current thinking.

1.2.1.1. Affect

Affect is a difficult term to define not least because it is often used interchangeably with words like emotion and feelings. It has been defined as the 'conscious, subjective aspect of an emotion considered apart from bodily changes' (Merriam-Webster, 2007-2008), but both the 'conscious' and 'subjective' descriptors may be debatable. Most research involving affect, for example, tends to focus on amygdala activation and the unconscious and automatic nature of the generative process (Bradley et al., 1988, Bradley et al., 1990, Bradley et al., 1993a, Bradley et al., 1999b, Bradley et al., 1992, Bradley et al., 1993b, Öhman et al., 2001, Vuilleumier, 2005). At one time, it was used by Titchener as a label for the pleasant-unpleasantness dimension of feeling (Reber, 1985) and it is this usage that appears most common, although the term 'feeling' may be contentious. In modern research, it is often regarded as one of the early components in emotion generation and is believed to have evolved from appetitive and aversive, approach and avoidance behaviour that proved to be adaptive (Bradley and Lang, 2000). Presumably via generalization processes, it has become attached to numerous objects and events that give rise to positive, negative and neutral affective responses.Whether biologically triggered as a hard-wired evolutionary response (Bradley and Lang, 2000) or the intuitive product of a cognitive process (Arnold, 1960), it is usually associated with amygdala activation. In the description of emotion generating mechanisms and emotion regulation strategies described above, affect is probably the definition of emotion that is referred to there.

1.2.1.2. Basic emotions

Conceptualizations of basic emotions are derived from Darwin's theory of evolution and the identification of a limited number of universal facial expressions that communicate feelings. Apart from the five basic emotions of fear, anger, disgust, happiness and sadness, there is no agreement on what constitutes a basic emotion or how many there are. Basic emotions are usually thought to be biologically generated and, for some, are the products of the particular muscle configurations that form the facial expression (Ekman, 2004). According to Ekman, basic emotions are adaptive ways of dealing with fundamental life tasks (e.g. to develop and regulate attachments, to accelerate or decelerate aggression) and share four common characteristics: they are all universal signals, have distinctive physiology, involve automatic appraisal, and have universal antecedent events such as the loss of a significant other (Ekman, 1999). For researchers with a more cognitive perspective, however, they may be linguistic labels used to describe the outcomes of cognitive appraisals involving value judgements based on goal relevance, social standards or attitudes and tastes (Clore and Ortony, 2000).

1.2.1.3. Response tendencies

The automatic physiological, experiential and behavioural responses that are triggered automatically via the thalamo-amygdala pathway in response to an external stimulus are called response tendencies. For some researchers, response tendencies are emotions (Gross, 1998a) but for others they may be viewed as only one type of emotional response in a process that more often involves more sophisticated cognitive evaluations that culminate in responses such as feelings of guilt or shame (Clore and Ortony, 2000).

1.2.1.4. States of action readiness

Researchers who focus on higher order emotional responses, such as guilt and shame, that are believed to be the outcomes of appraisals of stimuli in terms of self relevance and goal achievement, define emotions as states of action readiness (Frijda, 2004, Frijda, 2005, Oatley, 1992). Within this perspective, it is the motivation, or the 'urge' to carry out an action (i.e. to hit, shout, run, cry or sing) that characterizes an emotion and differentiates it from the alternative, objective response.

1.2.1.5. Feelings

As stated above, for some researchers and in common sense discourse, feelings are used synonymously with basic emotions and describe discrete emotions such as disgust and fear. For others however, since emotions are generated automatically and unconsciously, feelings are just an epiphenomenon of the emotion generating process that describe human experience, and which have no real relevance to the emotion generating process (LeDoux, 1996). Damasio, however, goes further and defines feelings as 'private, mental experiences of emotion' (Damasio, 2000) and describes them as 'a reflection of body-state changes' (Damasio, 2000), p22). Frijda on the other hand, maintains that they are the conscious experience of an emotion and, crucially, function to 'broadcast' messages to vast and disparate neural networks in order to recruit all potential resources for information processing

(Frijda, 2005). Thus they play a vital role in the construction of the reality by which we live and act. By activating some actions, stopping or interrupting others, changing expectations and adjusting beliefs and attitudes they are highly influential in determining behaviour. Although many researchers argue that feelings may simply give rise to post hoc rationalizations of unconscious appraisals of preceding events, Frijda maintains that 'sources, or presumed sources' can be retraced and explicated by reflection, deliberated and acted upon and thence inform subsequent behaviour (Frijda, 2005).

1.2.1.6. Summary

Athough the definitions above are very diverse, there now appears to be a move to understand emotion in terms of a process starting with the generation of primitive affect and ending with high level, self relevant appraisals of external stimuli that generate complex emotions and guide behaviour towards goal achievement (Kappas, 2006). Understanding emotion with this kind of temporal perspective makes sense of the multi-definitional alternatives for the concept of emotion outlined above and provides some clarity.

1.2.2. Methodologies: Measuring Emotion

Measures of emotional responses may tap into the thalamo-amygdala pathway or the thalamo-cortical pathway, or both. Depending on focus of interest, researchers may typically adopt a psychophysiological or psychoneurological approach or a mix of the two. Following the identification of the amygdala as a key mechanism in emotional responding (LeDoux, 1996), most researchers attempt to measure amygdaloid activity. Since the amygdala triggers behavioural and physiological responses, psychophysiologists tend to measure heart rate and skin conductance responses (SCR), or galvanic skin responses (GSR), as indicators of amygdala activity (Codispoti et al., 2001, Lang et al., 2000, Lang et al., 1993, Palomba et al., 2000). Often facial EMG is also recorded as a measure of emotional expression that provides indications of response valence (e.g. zygomaticus major activity: smiling; corrugator supercilli activity: frowning) (Lang et al., 1993, Vrana, 1993).

Neuropsychologists tend to focus on techniques such as electroencephalography (EEG) (Carretié et al., 1996, Esslen et al., 2003, Junghöfer et al., 2001, Palomba et al., 1997) that records brainwaves and offers good temporal information such as the precise timing of the onset and offset of amygdala activity. fMRI techniques identify good source location information for neural activity during emotional responding that can be used to describe functional neuroanatomy (Mitchell et al., 2007, Ochsner et al., 2002, Ochsner et al., 2004, Phan et al., 2005) and can provide EEG studies with highly reliable concurrent validity, although modern EEG equipment can now also provide source location information. PET scans, on the other hand, provide information regarding simultaneously active regions and the intensity of activation in each region. Neurological techniques are also used to identify *interactions* between brain regions and help trace important neural pathways between mechanisms (Phan *et al.*, 2002).

As Gross summarised in his consensual process model of emotion generation (Gross, 1998a), however, an emotion is multicomponential with concomitant physiological, behavioural, experiential and, perhaps, cognitive components. Therefore, as Bradley and Lang maintain, measures of emotional responding should tap into all components (Bradley and Lang, 2000). Whilst physiological responses provide indirect measures of amygdala activity, self reports are often used to access the experiential component (Beauregard et al., 2001, Jackson et al., 2000, Ochsner et al., 2002, Ochsner et al., 2004, Phan et al., 2005). Where appropriate, behavioural responses may be observed via video recordings, and reaction times provide indicators of cognitive activity.

1.3. Early Designs and Design Issues

1.3.1. Feelings versus Affect

According to Keltner et al (2003) the choice of studying emotion by category or dimension tends to follow theoretical approach. Evolutionary theorists suggest that each emotion triggers a specific adaptive response and therefore tend to focus on discrete emotions. Theorists who emphasise the socially constructed nature of emotion and differences across cultures, tend to favour a dimensional approach. The discrete emotion approach tends to focus on basic emotions. Often the number of basic emotions identified varies around the numbers five to seven but no agreement has yet been reached concerning the exact number. Fear, happy, sad, angry and disgust, however, always appear to be included in a list of basic emotions. Within the dimensional approach, all emotions are believed to lie on a continuum. A small number of dimensions are identified and emotions on any one dimension are thought to differ in degree of emotion only. Thus, a valence dimension situates positive and negative emotions on a continuum with fear, anger, disgust and sadness lying along the negative section and happy, joy and excitement along the positive. Since the aim was to investigate the common sense understanding of emotion the initial decision was to concentrate on feelings. A preliminary study was run to check responses to IAPs pictures in a British population. The results are discussed below.

1.3.2. Materials: slides versus film stimuli

Although film excerpts have been used successfully to elicit specific, discrete emotions (Gross & Levenson,, 1995; Hagemann et al, 1997; Palomba et al, 2000; Philippot, 1993) it was decided to use slides for design simplicity, to minimise expressive behaviour and to ensure that the stimuli were not age or culture specific. The decision to use the International Affective Picture Set (IAPS) was largely to ensure that the visual stimuli used had been standardised but also to be certain of meeting ethical requirements. The picture set includes a large variety of positive, negative and neutral pictures, and generates a picture viewing activity that is highly motivational and ecologically valid. It is a fairly passive activity, however, so motor movements are minimised and picture presentation carefully controlled. Although dimensional theorists have used the IAPS material (Palomba et al, 1997; Carretié et al, 1996; Carretié et al, 2001), it has been found to generate a number of discrete emotions and analysis of such studies have shown it to produce substantial 'stability of affective evaluations across laboratories in different countries' (Davidson et al, 2003 p.191). In addition, good associations have been found between picture valences and physiological responses and between physiological responses and evaluative judgements (Davidson et al, 2003). Differences in heart rate and skin conductivity measures have also differentiated between specific feelings such as fear, disgust and happiness (Lang et al, 1993). In order to select pictures from the IAPS picture set for use in the final experiments, a preliminary study was carried out to identify pictures that reliably generate discrete emotions.

Preliminary Study 1

One hundred and seventy one negative pictures and 196 positive pictures valenced by the Center for the Study of Emotion and Attention (CSEA-NIMH) were identified initially as potentially useful. The initial selection was limited to avoid boredom before a sufficient number had been identified for the task. Pictures that were thought to be potentially offensive were omitted from the selection as were a large number of repetitions of same category photographs e.g. in sport and food. Potentially offensive pictures were omitted to help avoid participant withdrawals at a later stage and to be sure of ethical acceptance.

The software programme Superlab was used to construct a computer programme that would present the pictures to participants and record their responses i.e. emotion labels, intensity ratings and reaction times. Thirty participants were asked individually to view the pictures and identify the emotion each picture generated. Each picture was presented for 100 milliseconds and then six emotion words appeared together with the picture on the screen. Five basic feelings were selected for presentation, *anger, fear, disgust, happy and sad* and two additional feelings, *calm and neutral.* These basic feelings were selected since they were believed to be universal, physiologically distinctive and easily verifiable.

Participants were selected via volunteer sampling and were paid for their time. The sample consisted of 9 men and 21 women in the twenty to fifty years age range. The mean age was 30.93 years. Use of an internationally tested picture set to generate the feelings standardised the procedure and also ensured ethical acceptability. No pictures were selected that were not found in the media although, prior to taking part, participants were also questioned about potential responses to fear, violence and disease to make sure that events in personal life histories would not cause distress.

The procedure was simple. Participants were instructed to look at each picture as it appeared on the computer screen, select the *best fit* emotion word to describe their response and record the intensity of their response by pressing the first letter of the selected emotion on the computer keyboard. A 5-point rating scale then appeared on the screen and participants were required to register the intensity of the emotion felt i.e. Low 1 2 3 4 5 High. Following the response, again recorded by pressing the appropriate key on the keyboard, the next picture appeared. Emotions and intensity ratings were then analysed using frequency data.

In addition to the main activity, a smaller study was also conducted to see if repeating the pictures a number of times would produce habituation. It was predicted that if participants habituated to both positive and negative pictures, response times would show a trend towards faster times as novelty decreased and cognitive processing was reduced.

In this study, seven pictures were randomly selected from the three picture categories with low, medium and high valence ratings to represent fear, neutral and happy emotions. Five different fear, neutral and happy pictures were selected for 1 presentation each. One picture from each category was selected for 5 presentations, and another picture from each category was selected for 10 repetitions. In total, therefore, 21 pictures were presented either once, five or ten times making a total of 60 presentations. A 5-point rating scale was again used to record the intensity of the feelings experienced. This closely matched the SAM arousal rating scale used at the CSEA-NIMH, in that it allowed participants to register how strongly they felt on a low to high scale but, not being a continuous pictorial scale depicting facial expressions, did not allow *between category* responses such as 1.5, 2.5, 3.5 and 4.5.

The design for picture presentation was simple. Five sets of pictures were constructed by placing the pictures into repetition categories and then randomly selecting one from each category to be assigned to the 5 sets. The sets were then shuffled, the order randomised and the sequence of pictures determined by selecting one picture from each set as follows:

S_1 S_2 S_3 S_4 S_5

S_2 S_3 S_4 S_5 S_1

S_3 S_4 S_5 S_1 S_2

S_4 ....

Superlab was again used to present the pictures only this time participants were required to register only the *strength* of the feeling experienced.

Results: A set of neutral and sad pictures that could reliably generate these responses more than 90% of the time was clearly identifiable. However, the number of pictures in each set was small: thirteen pictures labelled neutral and nine pictures labelled sad. Fear and disgust generating pictures were not so clearly identifiable. Only 4 fear generating pictures could be identified if the 90% fear response was accepted and only 3 disgust pictures: although all the disgust pictures attracted a 100% disgust response result.

Comments from participants indicated that the pictures often generated more than one response and a decision had to be made regarding which one to choose. Examples of simultaneous emotional responses were: excitement and fear in response to an ice-climber on a steep ice slope, anger and fear in response to a victim of violence, and sadness and fear in response to an accident or disease victim. Participants were also aware of dual responses involving a felt emotion and a politically correct choice of response.

Analysis of mean emotion ratings for all the pictures presented produced 62.6% with a mean of 3 or above (see Appendix 3). On a 5-point rating scale, 3 was judged to indicate a strong response. Within this strong response category, 16.4% of the pictures also clearly identified agreement on a single feeling i.e. 90% or more of participants identified the same feeling for the picture. Pictures generating fear, happy, sad, disgust and neutral responses were identified in this way. From the pictures showing high agreement for feeling generated and a strong response, 7 fear, 7 happy and 7 neutral pictures were selected to test habituation in the next study (see Appendix 1).

Analysis of the data from the habituation study suggested that participants were responding differently to the three picture categories but the orienting response, though indicating a tendency to fall with repeated picture presentations also showed inconsistencies (see Table 1). Mean intensity ratings for the three feelings were: fear 3.88, happy 2.91 and neutral 1.71.

Table 1 Mean intensity ratings for pictures and repetitions (Study 1)

	Fear	Happy	Neutral
x1	3.81	2.93	1.46
x5	3.85	2.92	2.29*
x10	3.97	2.87	1.38

*rounded to 2 decimal places

Discussion: Comparison of the mean intensity ratings and percentages for the emotion labels indicated that a set of IAPS pictures could be identified and used to generate emotional responses described by participants as fear, happy and neutral. However, analysis of the habituation data indicated that all pictures within categories were not equivalent. A high valence rating for the pictures selected for the x5 repetition in the neutral category indicated that it was closer to the happy rather than neutral category and was replaced.

Although, the preliminary study identified those IAPS pictures that would reliably generate emotions assigned the same labels by British participants, the number of pictures involved was small and although initial experimental designs used only a small number of pictures this was later found to be inadequate. Initially, early pilot studies used the small number of pictures with 90% or more agreement, but then lowered the percentage to 80%+ and then finally resorted to collapsing categories into positive, negative and neutral affect.

Both age and gender were found to influence perceptions of particularly positive pictures and these were later omitted from experiments. Culture too influenced both perceptions and physiological responses to both negative and neutral pictures. South East Asian students, for example, hardly responded to pictures depicting mutilated bodies whilst European students found such pictures the most shocking. On the other hand, European students found pictures of beds made up with white sheets and pillow cases very neutral, whilst South East Asian students often rated them as highly positive. Since self reported arousal ratings were taken as a measure of the experiential component of emotion, collapsing the categories from feelings to affect was essential. However, initially the focus was on *feelings* as outlined below.

1.3.3. Habituation and Emotion Regulation

Habituation is defined as, 'a decrease in responsiveness to a stimulus when that stimulus is presented repeatedly or for a prolonged time' (McSweeney,2002). Initial presentation of a stimulus produces a shift of attention as the brain adjusts to the new and unexpected stimulus. This response is called an 'orienting response' (Sokolov, 1963). At first the response is quite strong and produces changes in sensory, somatic, EEG and autonomic processing which interrupt on-going behaviour and increase attentional focus to incoming sensory information (Davidson et al, 2003). With repeated presentations of the stimulus, however, the orienting response gradually decreases and eventually stops. This is called habituation and is a simple example of learning in the nervous system.

Habituation occurs in a number of neurological and physiological structures. Research by Fischer et al (2000), for example, has demonstrated neural habituation in the visual cortex and the right medial temporal cortex including the amygdala and hippocampus. Wright et al (2001) has also found differences in habituation in the prefrontal cortices depending on whether the stimulus is pleasant or unpleasant i.e. repeated happy stimuli produce greater habituation effects than fearful stimuli. Differences in the valence of stimuli has also been found by Bradley et al (1993) in sub-cortical structures. They found that whilst the primary reflex circuit showed habituation effects, the secondary modulatory circuit did not. Thus, it was demonstrated that the amygdala does not habituate over time but remains responsive to unpleasant stimuli, an activation pattern believed to function as a warning system to potential threat. In the same study, they also found that heart rate and skin conductance responses habituate to both pleasant and unpleasant pictures but corrugator muscle responses habituate to unpleasant pictures only. Skin conductance was also found to be highly sensitive to novelty.

Since habituation responses eventually decrease, control would appear to be via repetition of stimuli. Number of repetitions and the duration of stimulus presentation are both used to produce decreases in the orienting response, but researchers do not appear to utilise a standardised procedure. Habituation appears to be achieved by increasing the number of repetitions or duration of stimuli until asymptotes are reached: at least ten to fifteen repetitions would appear necessary.

Since cognitive and physiological measures would be used to measure emotion regulation, the potential for habituation processes to confound the results is clear. It was decided, therefore to conduct a preliminary study to see if picture repetition could be manipulated to produce habituation asymptotes that would form a baseline from which to measure the effects of emotional regulation. The following preliminary study was therefore conducted to assess the possibility.

Preliminary Study 2

The aim of this study was to use the IAPS pictures identified in study one to repeat the test for habituation with an improved design and to test it for internal reliability and potential gender effects. Inconclusive evidence exists for gender effects in emotion generation. Although de Wied et al (1997) reported gender differences in an experiment investigating the effects of forewarning participants of impending violence and suspenseful drama, Phillipot (1993) investigating the induction and assessment of feeling states in the laboratory, and Lang et al (1993) investigating behavioural reactions to emotion inducing picture stimuli found no gender differences.

Twenty one experimental pictures and 60 mixed set pictures to be used as 'fillers' were selected from the first study to use as emotion generating stimuli. As before, 5 sets of pictures were constructed and used to sequence the pictures. Seven fear, seven happy and seven neutral pictures were selected for the experimental conditions. Twenty fear, twenty happy and twenty neutral pictures were interleaved with the experimental stimuli to encourage spontaneous responses and discourage the use of memory. As before, each of the 5 sets of pictures included 1 fear, 1 happy and 1 neutral picture to be presented once, 1 picture from each category to be presented 5 times and 2 examples of a fear, a happy and a neutral picture to be presented 10 times in total (2 x 5 sets). Pictures from the 7 selected for each category were then randomly selected for 1, 5 or 10 repetitions. Also as before the pictures were randomly allocated to the sets, the sets shuffled and randomly allocated to one of 5 set positions. One picture from each set was then taken in sequence, as before, until all the pictures formed a single set. Two versions of this design were constructed to test for internal reliability and order effects. Thirty two participants, 16 men and 16 women, all teachers at a known sixth form college and with an average age of 40.73 years completed the study.

Results: Mean intensity ratings were compared for habituation effects but again showed inconsistencies (see Table 2). Repetitions for happy pictures increased intensity ratings i.e. no habituation appeared to be demonstrated.

Table 2 Mean intensity ratings for pictures and repetitions (Study 2)

	Fear	Happy	Neutral
x1	4.01	3.22	1.25
x5	3.76	3.35	1.31
x10	3.58	3.39	1.16

However, analysis of the differences between intensity ratings for first picture presentation and the mean intensity rating for subsequent repetitions (a measure that allowed comparisons between pictures and across categories) showed some increases in intensity ratings.

Table 3 Mean differences between intensity ratings for first presentations and repetitions

	Increase	Decrease
Fear x5	0.01	-
Fear x10	0.05	-
Happy x5	-	0.21
Happy x10	-	0.21
Neutral x5	-	0.07
Neutral x10	-	0.07

Overall mean ratings for fear, happy and neutral feelings continued to show differences in response to each category (see Tables 3 and 4).

Table 4 Overall mean intensity ratings for pictures in the fear, happy and neutral categories

Fear	Happy	Neutral
3.79	3.32	1.24

A between subjects ANOVA showed no differences between versions tested ($F_{1,30} = 0.04$ $p>0.05$) and no gender differences ($F_{1,30} = 0.01$ $p>0.05$).

Discussion: Although the two repetition conditions showed falling trends in arousal ratings for happy and neutral pictures and hence provided evidence of required habituation, responses to negative pictures tended to rise and it was clear that the attempt to create asymptotes to form baselines from which to measure the effects of emotion regulation was not going to be successful. A search through the emotion literature confirmed the results. Although habituation to repeated negative pictures should produce habituation, responses to blocked negative pictures often tend to increase the intensity of responses(Smith et al., 2005), possibly making it difficult to control habituation in this way. It was decided, therefore, to abandon the attempt and rely on counterbalancing of conditions to offset the problem.

1.3.4. Measures of Emotion

Decisions regarding selected methodology were largely pragmatic. fMRI, PET scan and EEG equipment was not available and therefore rejected. A psychophysiological approach was adopted, therefore, and a Biopac System purchased for the recording and measurement of heart rate, galvanic skin response and facial EMG. Since the focus of interest had narrowed to affect generation, again for pragmatic reasons, self-report ratings of arousal were selected for accessing the experiential components. It was not thought that behavioural responses would be particularly relevant to a passive picture viewing activity, but a camera did provide evidence that participants followed instructions and viewed the pictures for the full duration of picture presentation. Responses and response times were also recorded in order to provide measures of task accuracy.

Measuring physiological responses to the generation of affect, however, is not unproblematic. Both increases (Lazarus et al., 1962, Palomba et al., 2000) and decreases (Bradley et al., 1993a, Lang et al., 1993, Palomba et al., 2000) in heart rates have been reported for pictures that induce feelings of fear. Increases (Vrana, 1993) and decreases (Bradley et al., 1993a, Sarlo et al., 2005)in heart rates have also been reported to feelings of disgust. Induced feelings of sadness and disgust, however, have been found to be equivalent (Lang et al., 1993). The potential for confounding responses to fear, disgust and sadness inducing pictures by collapsing them into a single negative category is, therefore, a risk and is acknowledged. However, it was decided to address the problem with the use of statistical tests to identify any significant differences in responses. To do this, negative pictures would be divided into three discrete subsets i.e. fear, disgust and sad according to agreed emotion labels. A fourth 'mixed' category would be comprised of pictures to which feelings of fear, disgust and sadness had been attributed but for which there was less than 50% agreement on a single feeling. Any significant differences in HR, GSR and EMG responses to these subsets would then be identified using standard statistical tests.

Before analysis, all raw data would be screened for outliers and those found adjusted by changing extreme scores to one unit larger (or smaller) than the next most extreme score in the distribution. Extreme scores would be those found to be more than 3 standard deviations from the mean (Tabachnick and Fidell, 2007).

1.3.5 Recognition Memory

Research by Kevin Ochsner (2000) into the awareness that accompanies recognition of affective images and the processes of recollection and familiarity that may underlie them has produced some interesting findings. For example, recognition accuracy (signal detection d') was found to be greater for negative stimuli than neutral, and negative stimuli tended to be recollected significantly more frequently via Remembering than by feelings of Knowing. Neither positive nor neutral stimuli showed this enhancement pattern. Furthermore, how deeply stimuli were encoded at study (i.e. whether or not people were judging the intensity of the content or the brightness of the image at the time of encoding) did not influence the pattern of results found. Ochsner suggests that enhanced remembering and recollection of negative stimuli is probably due to the mechanisms and processes that bias attention to processing their distinctiveness (Ochsner, 2000).

In the light of these findings, and as a purely secondary and exploratory activity, therefore, it was decided to include a surprise recognition memory task at the end of each experiment and collect recognition memory data using the remember/know (R/K) paradigm. It was thought that it might provide future directions for further research. Participants would be required to mark pictures that were recognised as having been in the programme with an R for remember, a K for know or an F for familiar, depending on the state of recognition awareness experienced. Effects of valence and arousal could then be analysed using attributed valence labels and arousal ratings from preliminary studies, together with similar valence and arousal ratings from IAPS. For recognition accuracy data, signal detection d' would be calculated using the Snodgrass and Corwin adjustment (Snodgrass and Corwin, 1988). Simple proportions of Remember(R), Know(K) and Familiar(F) responses would be calculated for comparisons across conditions as measures of experienced awareness. In his 2002 research, Ochsner also showed, however, that experienced states of awareness and the processes of recollection and familiarity that underlie them are not the same. It was decided to take measures of familiarity controlling for the recollection/familiarity overlap identified by Jacoby (1991) and tested by Ochsner (2000) by using the formula ((k/n)/(1-(r/n)) (where k = know responses, r = remember responses and n = the total number of possible responses). Potential response confidence, identified by Yonelinas (1994), would also be controlled via instructions (i.e. remember and know responses would both emphasise a degree of certainty). A lack of confidence would be more directly measured via the frequency of familiarity responses (see instructions in Appendix 1). Recognition would be measured via proportions of old pictures (hits) to new pictures incorrectly identified (false alarms) (Ochsner, 2000). Using the formula above for the familiarity measure, recollection would be calculated as 1 – familiarity. The results would then be discussed in the final chapter where any potentially interesting lines of research would be highlighted and noted for potential future research.

1.3.6. Final Decisions: Summary

From the results of the preliminary studies run, it was decided to use the slides rated for arousal and valence levels in the preliminary studies but to use them to generate and measure affect rather than feelings due to the small number of pictures that produced 80%+ agreement on feeling label. An added advantage was the potential for concurrent validity checks. Collapsing feelings into affect categories would provide enough stimuli to create the designs required without repeating any picture. It was also decided to control habituation via counterbalancing. Heart rate, GSR, facial EMG and self reported arousal ratings, together with a recognition memory test, were the selected measures of emotional responses.

Chapter 3

Self Regulation

Freud's theories of suppression and repression that still appear to underpin common sense discourses on emotion, were based on a historically specific hydraulic model of emotion that conceptualised anxiety in terms of the inability to 'let off steam', i.e. an inability to express distressing and disturbing feelings. Only through psychoanalytic therapy could abreaction (i.e. the expression and emotional discharge of unconscious material (as a repressed idea or emotion) by verbalization especially in the presence of a therapist) produce catharsis (i.e. a purification or purgation that brings about spiritual renewal or release from tension or elimination of a complex by bringing it to consciousness and affording it expression). However, such concepts as suppression, repression, abreaction and catharsis could not be tested scientifically and were only validated by introspection. Though ubiquitous concepts in common sense discourses, many psychologists were very skeptical of their value in understanding emotion regulation.

Today, with fMRI, PET scans and EEG, emotion regulation has become scientifically testable. James Gross, for example, has extensively researched the suppression of the expression of emotion, and cognitive reappraisal as methods of emotion regulation (Gross, 1998b, Gross, 1998a, Gross, 1999b, Gross, 1999a, Gross, 2002, Gross and Levenson, 1993, Gross and Levenson, 1997b). Initially, suppression of feelings themselves were not thought possible since emotions were believed to be automatically generated response tendencies. However, many researchers do not accept this definition of emotion, believing emotions to be cognitively generated as a result of conscious evaluations of the relevance of events to the self. Psychologists who do not believe that emotions are automatically generated have been supported by new research by Kevin Ochsner that has identified connections between the PFC and the amygdala and demonstrated the ability of the cortex to up and down-regulate amygdala activation (Ochsner et al., 2002, Ochsner and Gross, 2005, Ochsner et al., 2004). This has opened up the possibility of testing self regulation of the emotion itself.

As stated at the beginning of this chapter, it is important for psychologists to test common sense knowledge and particularly understanding of emotion and emotion regulation since it has very real effects on the lives of individuals, groups and societies. The following experiments, therefore, were designed to test direct regulation of affective responses to valenced pictures. This approach is slightly different from that of Gross, therefore, since it accepts the premise that emotion generation may not be entirely automatic and that conscious and intentional control may modulate *the emotion itself.* The focus, therefore, is on the cognitive control of *emotions* and not behavioural responses such as facial expressions, which for Gross and other researchers with an evolutionary perspective, may influence the experience of the emotion. It was hypothesised that if affective responses are under intentional control, *instructing* participants to 'Feel' and 'Not Feel' emotional responses to pictures, would produce a measurable difference in physiological as well as experiential responses. More specifically, it was predicted that arousal ratings would be lower when participants tried to control their feelings and higher when they did not. In addition, heart rate responses to negative pictures would be higher in the 'No Feel' condition than the 'Feel' condition and galvanic skin responses and facial EMG would be higher in the 'Feel' than the 'No Feel' condition.

1.1. Experiment 1

1.1.1. Participants

Sixty participants (51 female: 9male) (Mean age:19.63 S.D.3.96), all first year undergraduates took part in the study for course credits. All completed Spielberger's Trait Anxiety Questionnaire (Spielberger, 1983) before participating in the study and were allocated to a low average, average or high average trait anxiety group based on their anxiety scores. Trait anxiety mean and standard deviation for the whole group was 40.6 (12.26). All 60 participants were then divided into two groups of 30 for the between subjects condition and matched as far as possible for gender (26 females, 4 males; 25 females, 4 males), age in years (19.1 (2.37); 20.2 (5.07) and trait anxiety level (36.8 (6.00), 39.9 (10.43)). All gave written informed consent before participating.

1.1.2. Stimuli and Design

Sixty experimental pictures (20 negative, 20 positive, 20 neutral) selected from the earlier survey of pictures taken from the International Affective Picture Set (IAPS), and 79 neutral inter-stimulus images from previous pilot studies provided the experimental stimuli designed to manipulate valence and generate emotional responses. All 20 negative pictures had a 97%+ agreement on negative valence and a strong valence rating (mean: 3.85) measured on a 5-point rating scale. No purely fear inducing pictures were included in the negative category in this study. All 20 neutral pictures had 87%+ agreement on neutral valence and a strong neutral valence rating[1] (mean: 3.47) on the same 5-point rating scale. Positive pictures consisted of a combined set of IAPS and Google images selected for age relevance. The 79 neutral inter-stimulus images consisted of an assortment of geometric line drawings and colour blocks. All 20 negative pictures and neutral pictures were randomly assigned to 3 conditions designed to manipulate repetition: 5 randomised, single presentations: 5 blocked affect presentations: and 10 blocked affect presentations. The mean ratings for strength of valence for affect in each condition were computed to ensure comparability (see Table 5).

Table 5 Strength of Valence Ratings for negative, positive and neutral pictures in the three repetition conditions

	Negative	Neutral	Positive
x1	3.81	3.53	3.32
x5	3.86	3.51	3.41
x10	3.85	3.48	3.45

Five blocks of trials were constructed in order to limit presentation time to 5 minutes maximum per block (see Table 6).

Table 6 Blocked Experimental Design

Block 1	x5 randomised negative, positive & neutral pictures
Block 2	x5 blocked negative, positive & neutral pictures
Block 3	x10 blocked negative pictures
Block 4	x10 blocked positive pictures
Block 5	x10 blocked neutral pictures

[1] Ratings are Valence Ratings not Arousal Ratings

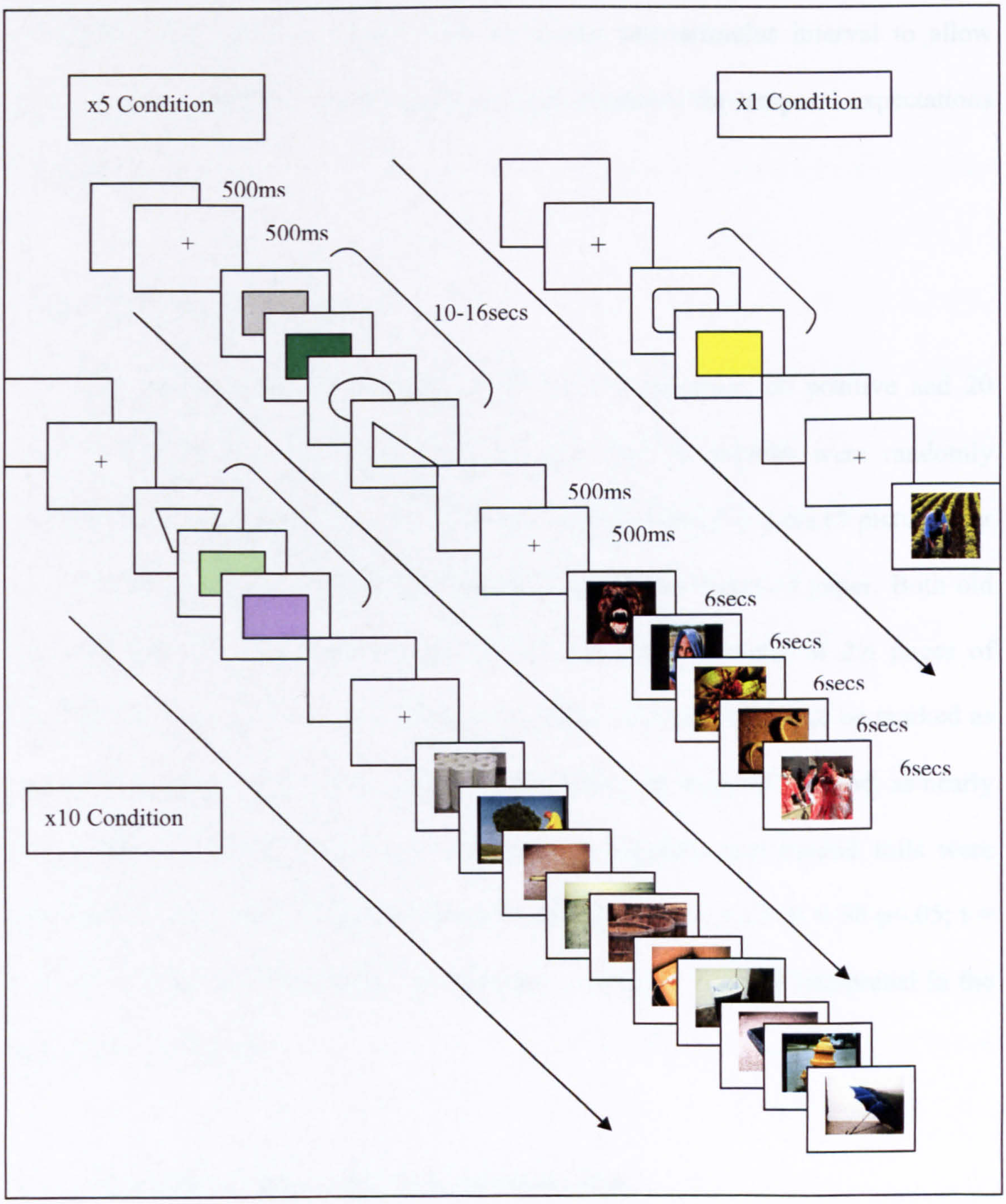


Figure 5 Trial Structures

Two versions of the design and three different picture sequences were constructed to enable full counterbalancing of blocks 3, 4 and 5 and valence in block two. All blank screens and fixation crosses were presented for 500ms and all experimental pictures for 6 seconds. The number and duration of inter-stimulus geometric shapes and colour blocks varied in number from 2-4 and in duration from 4000-8000ms in order to ensure a 10-16 second inter-stimulus interval to allow galvanic skin responses to fall to baseline, and to control for temporal expectations (see Figure 5).

1.1.2.1. Recognition Memory

One hundred and twenty pictures, 60 old (20 negative, 20 positive and 20 neutral) and 60 new (20 negative, 20 positive and 20 neutral) were randomly selected for the recognition memory task and were presented as rows (5 pictures per row) of coloured 2cm x 2.5cm thumbnails on laminated sheets of paper. Both old and new pictures were randomly positioned and formed a total of 2½ pages of pictures. Acetates placed over the laminated pages enabled pictures to be marked as seen, if recognised. Foils were matched by category (see Appendix 2) and, as nearly as possible, by intensity but t-tests showed that negative and neutral foils were significantly less intense than the experimental pictures ($t = 4.27$ $df = 38$ $p<.05$; $t = 3.58$ $df = 38$ $p<.05$). Results for the recognition memory task are interpreted in the light of this limitation.

1.1.3. Physiological Data Collection and Reduction

Superlab Software (Version 2.02) was used to programme and display the IAPS pictures on a standard IBM computer with a 17" colour monitor situated approximately 1.0m from the participant. A second IBM compatible computer running AcqKnowledge 3.7 Acquisition, Analysis and Archive Software controlled physiological data acquisition. Physiological signals were continuously sampled at 1000Hz and began at least 3 seconds before each series of pictures in each block.

Raw electromyography (EMG) was recorded from the corrugator supercilii muscle (above the left eye) and zygomaticus major muscle (left cheek) using four EL504 1" cloth disposable electrodes. Placement followed guidelines by Fridlund and Cacioppo (2000). The electromyographic activity was routed through a Biopac 150 system. The raw EMG signals were amplified (Gain: 5000) and filtered (low pass filter: 500Hz; high pass filter 10Hz) using a Biopac EMG100C Electromyogram Amplifier Module. The raw signals were rectified and integrated off-line following Biopac recommended procedures and averaged over 50 samples. Digital pulses marked the onset and offset of picture presentations. The magnitude of electromyographic activity was measured 1 second prior to picture onset and for the 6 second duration of picture presentation using the Biopac peak-to-peak(P-P) function.

Galvanic skin responses were recorded using 2 EL507 pre-gelled (Isotonic Gel) disposable electrodermal activity electrodes placed on the volar (palmar) surface of the distill phalanges (the fingerprint region) of the non-dominant hand. Electrodermal signals were routed through a Biopac GSR100C Electrodermal Activity Amplifier module. The raw signal was amplified (Gain: 5μS/v) and filtered (low pass: 1.0Hz; high pass: 0.5Hz) following Biopac Application note AH187 and calculated offline in microsiemens (μS) smoothed over 200 samples.

The electrocardiogram was recorded from the left and right side of the chest using 2 EL503 vinyl 1⅜" pre-gelled disposable general purpose electrodes. The signal was filtered using a Biopac ECG100 Electrocardiogram Amplifier. The signal was amplified (Gain: 500Hz) and filtered (low pass: Norm; High Pass 0.5Hz) following Biopac application note AH109. Offline calculation converted the raw signal to beats per minute (BPM).

1.1.4. Procedure

Prior to running the study, emails and fliers were circulated to advertise it and volunteers contacted and interviewed. In order to screen out unsuitable participants on ethical or experimental grounds, the nature of the study was explained during the interview and checks made regarding phobias, past experiences, potentially distressing memories that may be triggered by the pictures viewed, and pacemakers. Suitable participants then completed the Spielberger Trait Anxiety Questionnaire (Spielberger, 1983) which was later scored and used to assign participants from low average, average and high average anxiety groups to one of the two matched between subject groups.

On arriving at the laboratory, participants read the participant information sheet outlining the purpose of the study, were reminded of the procedure and then gave written informed consent to participate. Once seated approximately 1.0m from the computer screen, electrodes were attached, the equipment tested and waveforms checked. Participants were then talked through the instructions (see Appendix 1) and practice session. Approximately 20 minutes after the GSR electrodes were attached, the experiment began.

All participants completed block 1 followed by block 2 of the picture series and then blocks 3, 4 and 5 in the sequence required by counterbalancing procedures. All blocks required participants in the 'Feel' condition to look at each experimental picture and rate how strongly they responded to each one on a 5-point rating scale ranging from 1 Very Weak to 5 Very Strong, by pressing the apppropriate key on a response pad resting on the knees to minimise hand movements. They were instructed to register their *first* response as quickly but as accurately as possible but to continue looking at the screen for the full 6 seconds of picture presentation. They were also instructed to concentrate on the *strength* of the feeling and ignore the valence. Participants in the 'No Feel' condition followed the same procedure except that they were instructed to look at each picture, 'Stop' the emotional response and then rate the strength of any remaining response.

At the end of the experimental tasks, a short block of 'Feel Good' pictures (all positive pictures) was presented to create a positive mind set in which to complete the computer tasks. Participants completed the Spielberger State Anxiety Questionnaire (Spielberger, 1983) and then the recognition memory task. The recognition memory task required participants to look at the set of printed pictures placed on a table in front of them to see if they recognised any of the pictures as having been displayed in the experimental tasks they had just taken part in. They were instructed to leave blank any picture that they didn't recognise but to write the letter R in the centre of a picture they remembered having seen (i.e. a picture they could remember coming up on the screen, or a particular part of the picture they remembered, or something they had thought about at the time), a K if they *knew* they had seen the picture but had no mental 'evidence' to support the knowledge, and an F if a picture was accompanied only by a feeling of familiarity. Once completed, the electrodes were then removed and a few short post-experimental questions asked to record the participants experience of the study. In particular, participants in the No Feel condition were asked whether or not they felt that they had managed to Stop their emotional responses to the pictures and, if so, how.

1.1.5. Results

A mixed Analysis of Variance (multivariate) (ANOVA) statistical test was used to analyse the results for each dependent variable. The Feel/No Feel instruction formed the between subjects variable. All other variables were within subject variables. The results were analysed in three categories: physiological responses i.e. heart rate (HR), galvanic skin responses (GSR) and electromyographic activity (EMG), experiential responses i.e. self-reported arousal ratings, and cognitive responses i.e. the recognition memory test.

Change scores were calculated for all physiological responses. A change score is a response to an experimental stimulus minus a 1 second pre-picture onset baseline measure. The response score so calculated equals the response brought about by the experimental stimulus. HR change scores were calculated in beats per minute (BPM), GSR in microsiemens and EMG in microvolts. A Greenhouse Geisser correction for sphericity was used in all experiments where Mauchly's Test of Sphericity indicated sphericity violations. A mixed ANOVA was used to test HR and GSR differences between the negative category subsets of disgust, sadness and mixed negativity (see Chapter 2 p39). Using the independent variable 'Emotion' and three levels of analysis (i.e. disgust, sadness and mixed negativity), no main effect of emotion was found for HR ($F<1$), no main effect of group ($F_{1,58} = 1.4$ $p > .05$) and no Emotion x Group interaction ($F<1$). However, a main effect of emotion was found for GSR ($F_{1.66,96.32} = 11.65$ $p < .001$), but there was no main effect of group ($F<1$) and no Emotion by Group interaction ($F<1$). An analysis of simple effects revealed significant differences between galvanic skin responses to feelings of disgust and sadness ($F_{1,58} = 14.51$ $p < .001$ $d = .20$) and disgust and mixed negativity ($F_{1,58} = 15.94$ $p < .001$ $d = .22$) but no significant difference between feelings of sadness and mixed negativity ($F_{1,58} = 3.08$ $p > .05$). However, though differences in responses may have attenuated the habituation trend seen in Figure 7, and may have *reduced* the effect size of the differences between responses to negative and neutral pictures, the lack of a main effect for group and no Emotion x Group interaction meant that the Feel and No Feel conditions were unaffected. Therefore, it was judged acceptable to compare differences between negative and neutral stimuli using the collapsed negative category.

1.1.5.1. Physiological Responses

In line with existing research, there was a main effect of valence for HR ($F_{2,114} = 3.92$ $p < 0.03$ $d = .06$) and GSR ($F_{1.06,62.9} = 7.28$ $p < 0.01$ $d = .11$) but changes in heart rates were greatest for neutral pictures and lowest for positive pictures (see Table 7). For GSR, changes were greatest for negative pictures and smallest for neutral pictures (see Table 7).

Table 7. Means and Standard Errors for HR and GSR responses to negative and neutral pictures (change scores)

	Negative		Positive		Neutral	
	Mean	S.E.	Means	S.E.	Mean	S.E.
HR	-.41	.22	.06	.16	-.59	.16
GSR	.03	.01	.02	.00	.01	.00

There was also a main effect of repetition (HR: $F_{2,114} = 12.59$ $p < 0.001$ $d = .18$ and GSR: $F_{1.2,72.34} = 8.62$ $p < 0.001$ $d = .13$) with the largest fall in heart rate in the x5 condition and the smallest rise in GSR in the x10 condition (see Table 7). There was also an interaction effect of Valence x Repetition for both HR and GSR (HR: F

$_{4,228}$ =2.49 p<0.05; GSR: $F_{1.18,69.72} = 3.68$ p <.05 d = .06) with heart rate changes to negative and neutral pictures steadily rising with increases in same valence repetitions and GSR steadily falling (see Figures 6 and 7). Table 8 reports the exact mean change responses.

Table 8 Heart Rate and Galvanic Skin Response Means and Standard Errors for negative and neutral pictures in all three repetition conditions

	HR						GSR					
Repetitions	Negative		Positive		Neutral		Negative		Positive		Neutral	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
x1	-.96	.37	.18	.35	-.77	.32	.05	.01	.02	.00	.01	.00
x5	-.72	.31	-.78	.25	-.64	.26	.03	.00	.02	.00	.01	.00
x10	.46	.27	-.77	.20	-.37	.23	.01	.01	.01	.00	.01	.00

However, there was no main effect of instruction for either HR (F<1) or GSR (F<1) and no additional interaction effects (Valence x Instruction: HR: $F_{2,114} = 1.21$ p>.05; GSR: $F_{2,116} = 1.99$ p>.05), (Repetitions x Instruction: HR: $F_{2,114} = 2.80$ p>.05; GSR: $F_{2,116} = 1.67$ p>.05), and (Valence x Repetition x Instruction: HR: $F_{3.28,187.28} = 1.52$ p>.05; GSR: $F_{1.18,68.21} = 1.08$ p>.05).

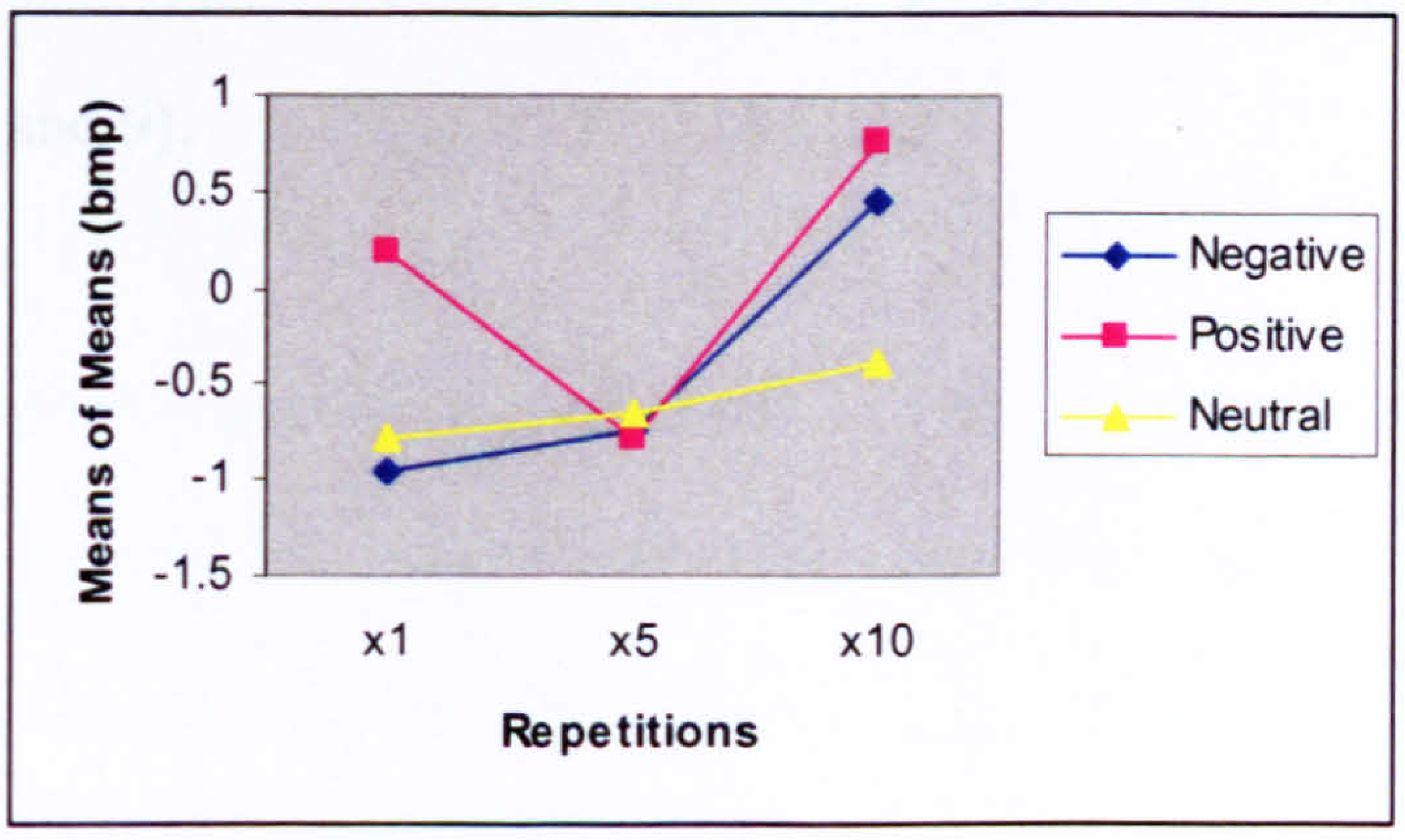


Figure 6: Heart rate responses to repeated negative, positive and neutral pictures

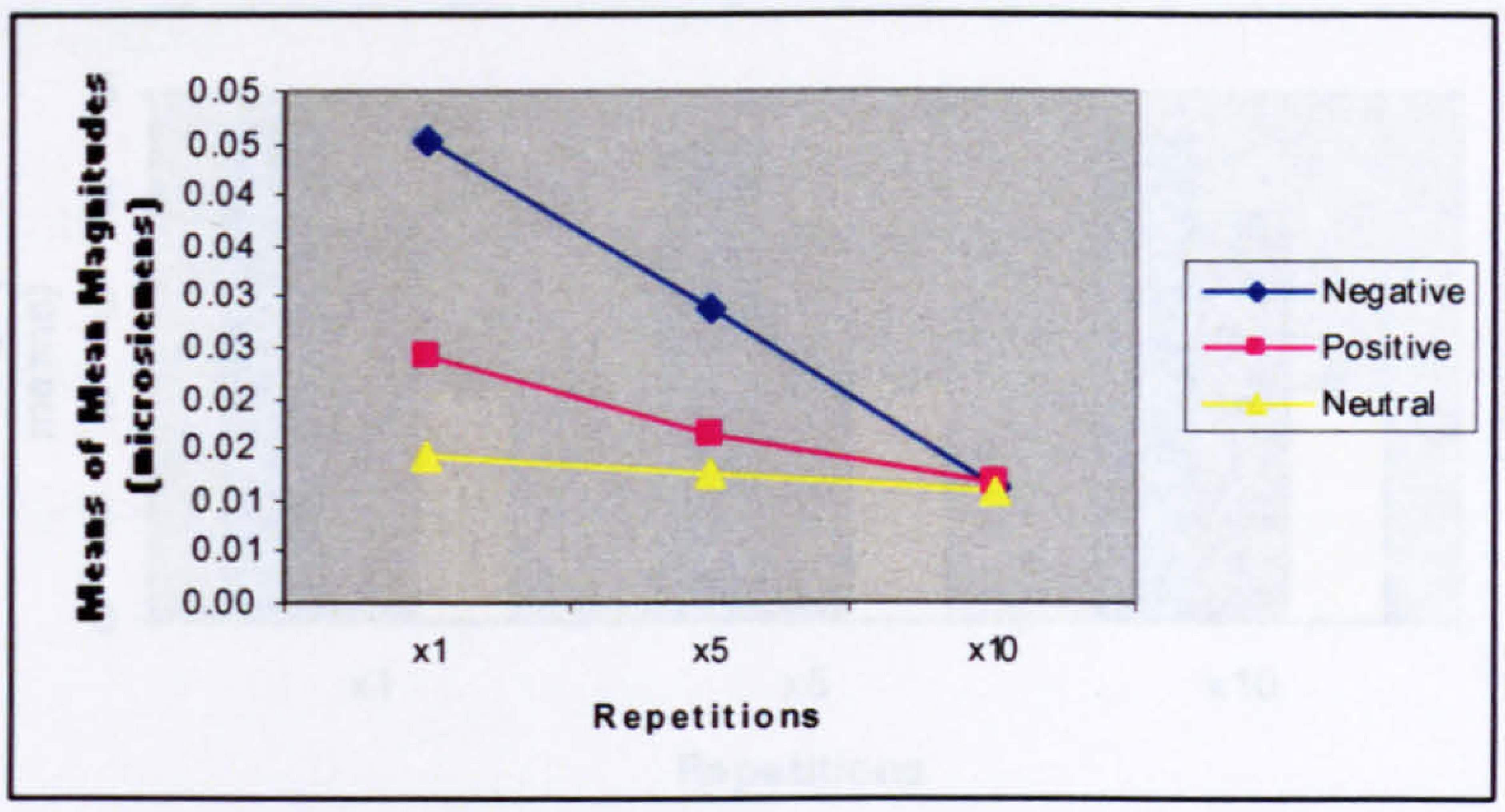


Figure 7: Galvanic skin responses to repeated negative, positive and neutral pictures

1.1.5.2. Arousal Ratings

For self-reported arousal ratings, there was a main effect of valence, as expected, ($F_{1.48,84.35} = 298.62$ $p < 0.001$ $d = .83$) with significantly higher arousal ratings for negative than neutral pictures (Means and SEs = 4.05, .081; 1.95, .077 respectively) and a main effect of repetition ($F_{1.75,99.7} = 5.87$ $p < 0.01$ $d = .09$) with arousal ratings significantly lower in the x10 condition than in the x1 condition (Means and SEs = (x1) 3.10, 0.73, (x10) 2.95, 0.73). There was also a main effect of instruction ($F_{1,57} = 69.88$ $p < 0.001$ $d = .55$) with significantly higher ratings in the Feel than the No Feel condition (Means and SEs = (Feel) 3.53, .09; (No Feel) 2.56, .09) (see Figures 8 and 9).

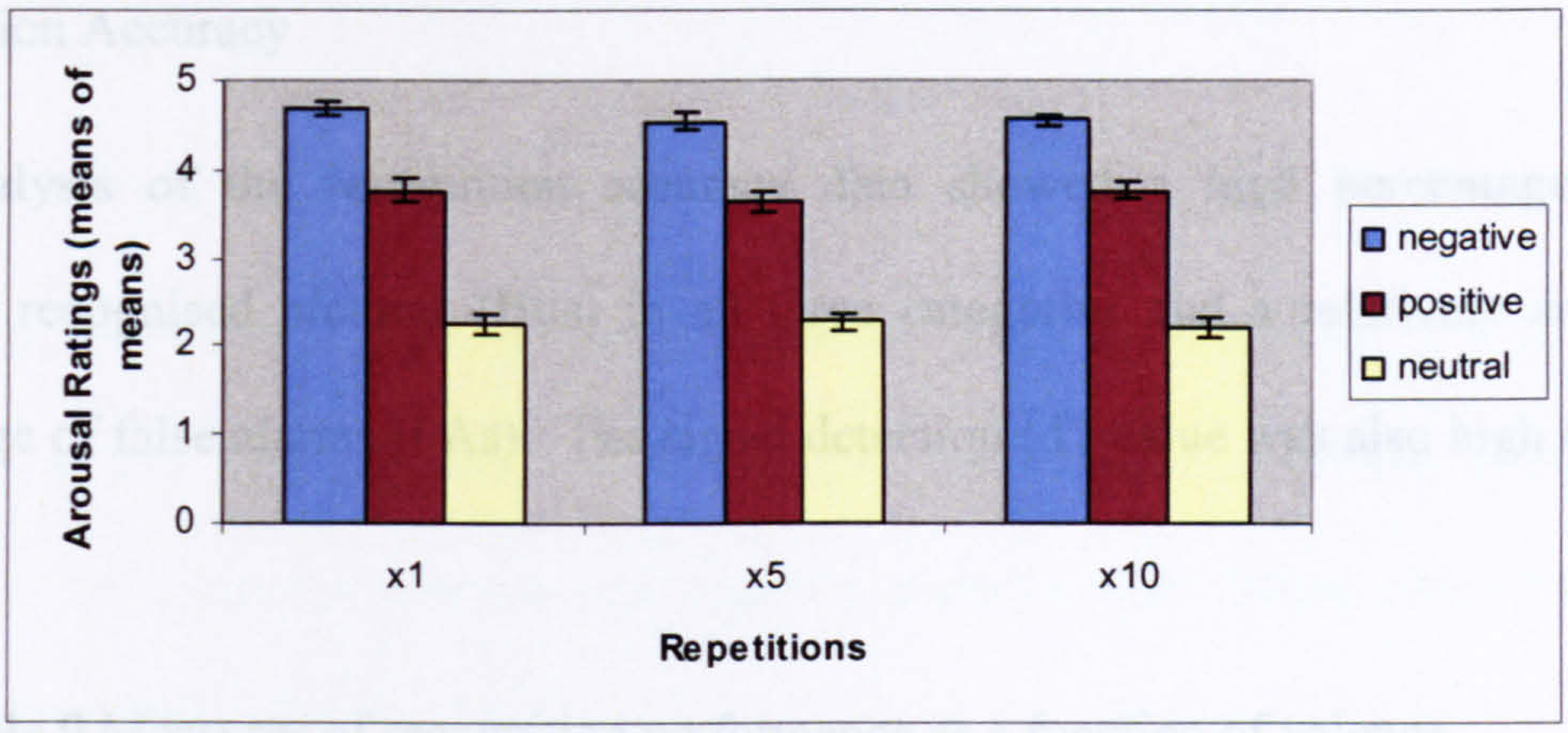


Figure 8: Self reported arousal ratings for repeated negative, positive and neutral pictures in the Feel Condition

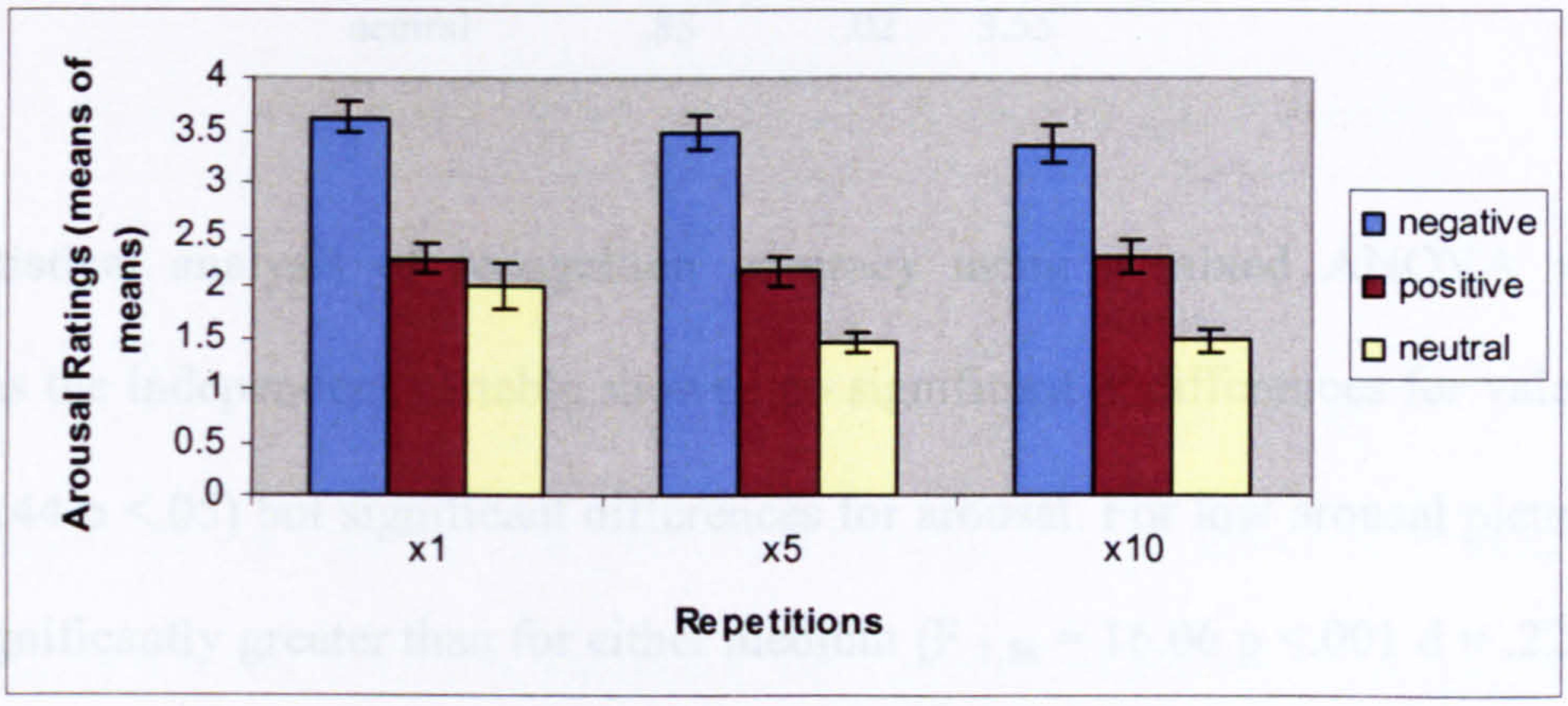


Figure 9: Self reported arousal ratings for repeated negative, positive and neutral pictures in the No Feel Condition

1.1.5.3. Recognition Memory

In this experiment, valence was assigned to pictures according to the affect labels identified in preliminary studies and IAPS valence ratings. Arousal refers to high, medium and low arousal ratings given to negative, positive and neutral pictures (i.e. negative = high, positive = medium, neutral = low).

Recognition Accuracy

Analysis of the recognition accuracy data showed a high percentage of correctly recognised pictures (Hits) in all three categories and a relatively small percentage of false alarms (FAs). The signal detection (d') value was also high (see Table 9).

Table 9 Measures of recognition performance as a function of valence

Valence	Hits	FAs	d'
negative	.91	.04	3.11
positive	.88	.01	3.23
neutral	.85	.02	3.55

Statistical analysis of recognition accuracy using a mixed ANOVA with valence as the independent variable showed no significant d' differences for valence ($F_{1,58} = 2.44$ $p < .05$) but significant differences for arousal. For low arousal pictures, d' was significantly greater than for either medium ($F_{1,58} = 16.06$ $p < .001$ $d = .22$) or low arousal pictures ($F_{1,58} = 31.48$ $p < .001$ $d = .35$).

An analysis of correctly recognised pictures using a mixed ANOVA statistical test showed a main effect of valence ($F_{2,116} = 5.76$ $p < 0.01$ $d = .09$) with significantly more negative pictures being correctly recognised than positive ($F_{1,58} = 14.90$ $p < 0.001$ $d = .20$) (Means and S.E.s = negative .304 (.00), positive .295 (.01), neutral .284 (.01). There was no significant difference between the proportions of negative and neutral pictures correctly recognised ($F_{1,58} = 2.33$ $p > 0.05$ $d = .04$), however, nor between the proportions of positive and neutral pictures recognised ($F_{1,58} = 2.85$ $p > .05$ $d = .05$) (see Figure 10). There was no main effect of group ($F<1$), and no Valence x Group interaction ($F_{2,116} = 1.05$ $p > .05$ $d = .02$).

Remember, Know and Familiar responses

Comparisons of simple proportions for the three picture types and R/K/F responses in the Feel and No Feel conditions (see Table 10) showed a higher proportion of correctly remembered negative pictures than either remembered positive or neutral pictures.

Table 10 Simple proportions of R/K/F recognition responses to negative, positive and neutral pictures in the Feel and No Feel conditions.

	Feel			No Feel		
Valence	Remember	Know	Familiar	Remember	Know	Familiar
Negative	.78	.07	.04	.79	.12	.03
Positive	.53	.22	.10	.56	.17	.13
Neutral	.38	.39	.12	.56	.25	.09

Analysis of the data by R/K responses showed a main effect of recognition ($F_{2,116} = 86.98$ $p <.001$ $d =.35$, a Valence x Recognition interaction ($F_{1.88, 109} = 31.49$ $p < .001$ $d =.35$ (see Figure 10), and a Valence x Recognition x Group interaction ($F_{1.9, 109} = 2.97$ $p <.05$ $d = .05$). For negative and positive pictures, all R, K and F comparisons were significantly different. For neutral pictures, however, the R/K comparison was not significantly different ($F_{1,58} = 2.98$ $p >.05$). Analysis of the three-way interaction showed a significant difference in group R/K responses to all picture types. For negative pictures, there was a significant difference in R/K responses in the Feel ($F_{1,29} = 137.63$ $p <.001$ $d =.83$) and No Feel ($F_{1,29} = 58.84$ $p <.001$ $d =.66$) conditions as there was also for positive pictures (Feel $F_{1,29} = 16.48$ $p <.001$ $d = .36$; No Feel $F_{1,29} = 21.18$ $p <.001$ $d = .42$). Neutral pictures showed a significant difference in R/K responses in the Feel condition ($F_{1,29} = 5.99$ $p <.01$) but not in the No Feel condition (F<1). A comparison of correctly recognised negative and neutral pictures in the Feel and No Feel conditions showed that although significantly more negative than neutral pictures were remembered in both the Feel ($F_{1,29} = 42.13$ $p < .001$ $d = .59$) and No Feel ($F_{1,29} = 13.70$ $p < .01$ $d = .32$) conditions, the size of the difference between them in the No Feel condition (d=.32) was almost half that found in the Feel condition (d=.59) i.e. the negativity bias was much smaller than would normally be expected (see Figure 11).

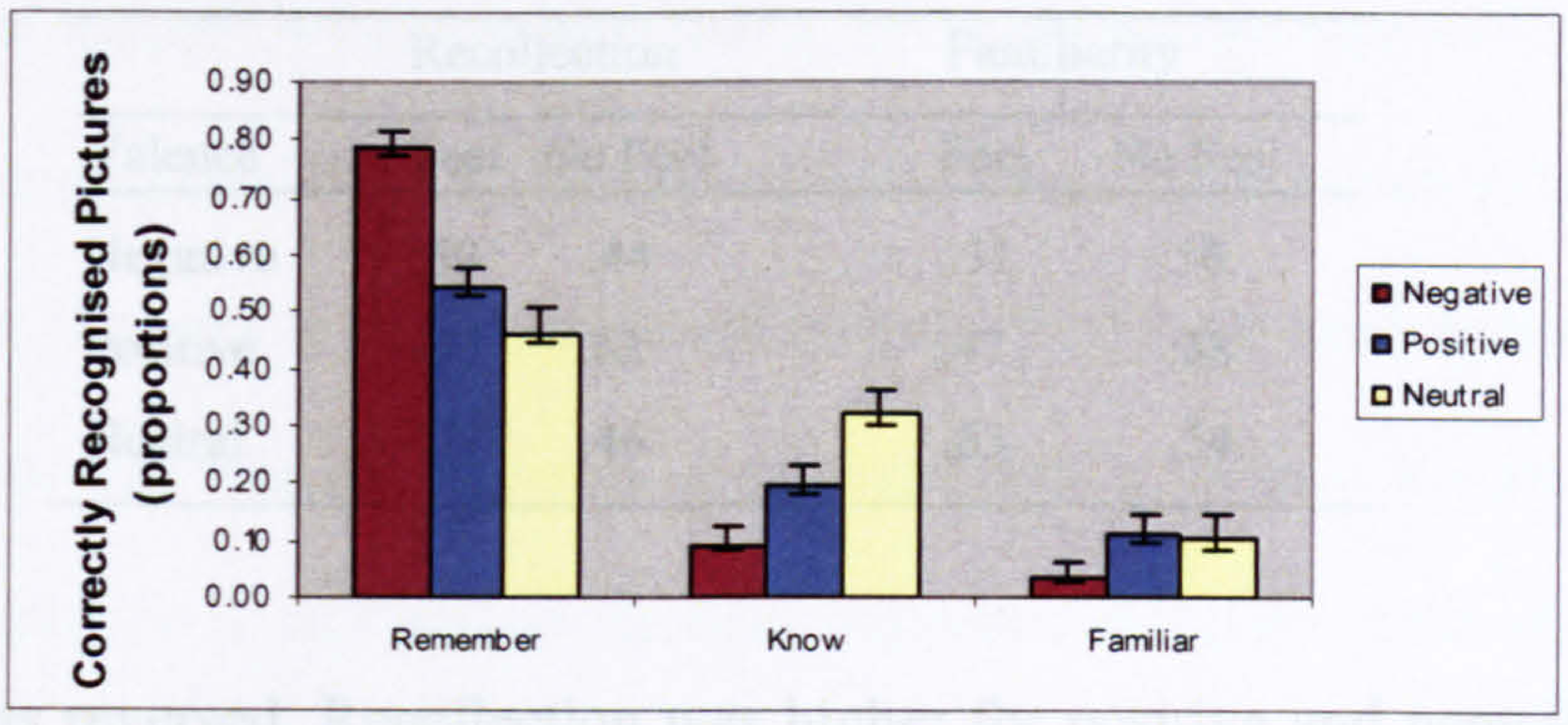


Figure 10: Proportions of remember, know and familiar responses as a function of valence

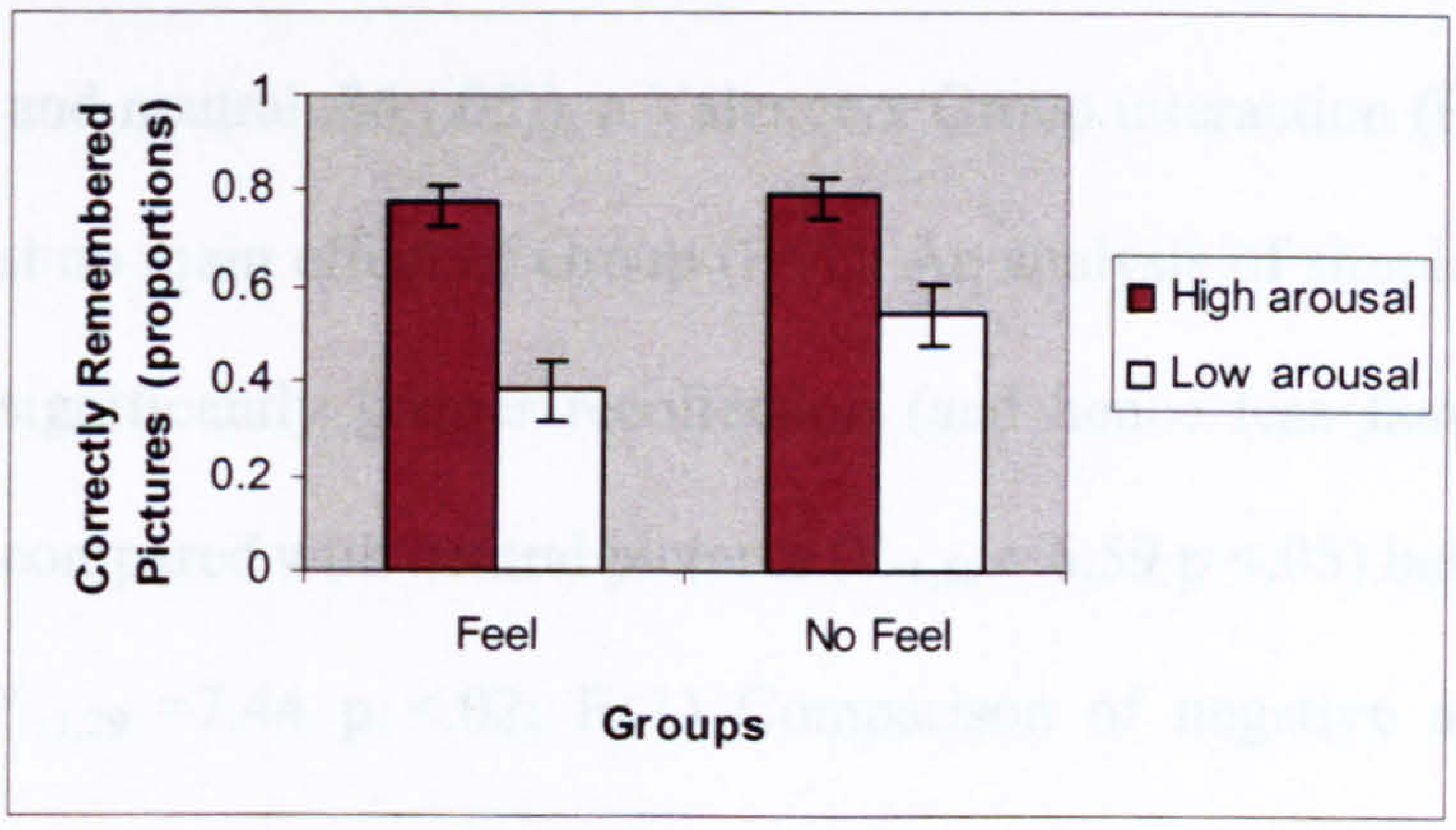


Figure 11: Proportions of correctly remembered pictures as a function of arousal

Recollection and Familiarity

An analysis of recollection and familiarity data showed that recollection was higher than familiarity for negative pictures in the Feel condition compared with positive and neutral pictures (see Table 11). However, in the No Feel condition

Table 11 Recollection and familiarity as a function of valence

	Recollection		Familiarity	
Valence	Feel	No Feel	Feel	No Feel
Negative	.69	.44	.31	.56
Positive	.53	.62	.47	.38
Neutral	.37	.46	.63	.54

The pattern was reversed. Recollection was higher for positive and neutral pictures than for negative.

Analysis of familiarity measures using a mixed ANOVA showed a main effect of valence ($F_{2,116} = 6.01$ $p <.01$ $d = .09$) (Means and SEs = negative .24 (.04); positive .37 (.04) and neutral .36 (.05)), a Valence x Group interaction ($F_{2,116} = 3.59$ $p <.05$ $d = .06$) but no main effect of Group ($F<1$). An analysis of simple effects for valence showed significantly greater recollection (and hence less familiarity) for negative pictures compared with neutral pictures ($F_{1,58} = 6.59$ $p <.05$) but only in the Feel condition ($F_{1,29} = 7.44$ $p <.02$; $F<1$) Comparison of negative and positive pictures found a similar pattern with greater recollection (and hence less familiarity) for negative than positive pictures ($F_{1,58} = 11.10$ $p <.01$ $d = .16$) in the Feel condition ($F_{1,28} = 16.12$ $p <.001$ $d = .36$) but not the No Feel condition ($F<1$). There were no significant differences between neutral and positive pictures ($F<1$).

1.1.6. Discussion

The aim of this study was to investigate the potential of participants to regulate their emotional responses in line with Feel or No Feel instructions whilst viewing external emotion generating stimuli (i.e. negative and neutral pictures). The results showed no evdence that conscious self instruction could modulate HR and GSR physiological responses despite a significant main effect of instruction on self-reported arousal ratings. What was interesting, however, was an effect of instruction on recognition memory. The fact that there was no valence x instruction interaction in performance data shows that instructions had no effect on overall proportions of negative and neutral pictures correctly recognised, but a valence x recognition x instruction interaction in recognition memory suggested that it did have an effect on *how* pictures were remembered. The proportion of negative to neutral pictures remembered in the No Feel condition, for example, was significantly less than in the Feel condition. This suggests that an important effect of the instruction to consciously and intentionally control emotional responses to negative pictures was to produce a dampening of emotion in recognition memory, and this may indicate that some degree of top-down control may influence how strongly or how detailed a negative picture may be encoded in recognition. Exactly how this occurs, however, is still unclear, but one possibility is via increased activation from executive mechanisms. Research suggests that paying attention to a stimulus improves memory (Cowan, 1993) and that attention is modulated by top-down biases from the PFC (Maia and Cleeremans, 2005). If this is so, then conscious instructions may bias attentional resources, either to increase or decrease processing resources and thereby memory. However, it must be re-emphasised that recognition memory data was collected for exploratory use only and no definitive conclusions can be drawn from this data. What it does do is offer potential lines of investigation for future research and this will be discussed in the final chapter.

Although the overall line of inquiry appeared interesting, there was some concern that the untested originality of the present experimental design might not stand up to a rigorous peer review and would therefore throw doubt on the validity of any results produced. The decision was taken, therefore, to run a second experiment with a more rigorous within subjects design to test the same hypothesis (i.e. that a conscious instruction to Feel or Not Feel emotional responses to external stimuli would produce a significant difference in emotional response) before continuing.

In the new design, inter-stimulus geometric shapes and colour blocks, included to avert boredom and prevent temporal expectations of experimental picture presentation, would be replaced by a simple fixation cross that varied in temporal duration. Boredom would be controlled by the division of tasks into blocks of picture presentations lasting a maximum of approximately 3 minutes. The relatively untested positive images selected for age appropriacy would also be excluded, limiting the study to a comparison of just negative and neutral pictures, and the blocked 5 consecutive single affect picture presentation condition would also be omitted since it offered no additional insights that the 10 consecutive presentation condition didn't provide. Second year undergraduates would also be recruited rather than the first years to help offset possible demand effects and, finally, a video camera would be introduced to confirm participant focus on experimental pictures for the full 6 second duration of picture presentation. With design improvements, the experiment was then re-run.

1.2. Experiment 2

1.2.1 Participants

Thirty two participants (25 females: 7 males)(Mean age: 20.31yrs SD 1.66), all Leeds University second year undergraduates, took part as paid volunteers. All completed Spielberger's Trait Anxiety Questionnaire (Mean: 39.78 SD 7.4) before participating in the study to exclude any abnormally highly anxious individuals and to ensure matched samples in version groups. All participants gave informed written consent to participate.

1.2.2. Stimuli and Design

Eighty experimental IAPS pictures (40 negative: 40 neutral) selected from the previous preliminary studies were randomly assigned to two sets of pictures (20 negative: 20 neutral) to construct the Feel and No Feel conditions. Each set was then divided again to form the 2 repetition conditions (x10 randomised negative and neutral presentations: x10 blocked single valence). Ten blocks of trials were then constructed as follows so that no block lasted longer than approximately 3 minutes (see Table 12).

Table 12 Experimental Design

FEEL Block 1 Practice	TRIAL STRUCTURES	NO FEEL Block 1 Practice
Block 2 Randomised x1 Block 3 Randomised x1 Block 4 Blocked x10 Negative Block 5 Blocked x10 Neutral	+ IAPS Randomised x10 12-16s 6 secs Blocked x10 12-16s 6 secs	Block 2 Randomised x1 Block 3 Randomised x1 Block 4 Blocked x10 Negative Block 5 Blocked x10 Neutral

The 12-16 second inter-stimulus fixation cross was maintained to disrupt temporal expectations. Four versions of the design were then constructed to ensure that all pictures appeared in both conditions and were counterbalanced.

1.2.2.1. Recognition Memory

One hundred and sixty pictures: 80 old (40 negative: 40 neutral) and 80 new (40 negative: 40 neutral) were selected for the recognition memory task and were presented on laminated sheets of paper as coloured 2cm x 2.5cm thumbnails arranged on three pages in 8 rows with 6 pictures per row and a fifth page of the remaining 16 pictures. Acetates placed over the laminated sheets enabled recognised pictures to be identified with the letters R (remember), K (know) and F (familiar). All foils and experimental pictures selected were matched by category (see Appendix 2). IAPs ratings were used to match arousal levels although arousal ratings for negative foils were significantly lower than for the negative experimental pictures ($t = 2.5$ $df = 78$ $p<.05$), as were the neutral foils ($t = 3.62$ $df = 68.88$ $p<.05$).

1.2.3. Physiological Data Collection and Reduction

As in experiment 1, Superlab Software (Version 2.02) was used to programme and display the IAPS pictures on a standard IBM computer with a 17" colour monitor situated approximately 1.0m from the participant. A second compatible computer controlled physiological signals sampled at 1,000Hz. . Heart rate (HR), galvanic skin responses (GSR) and electromyography (EMG) for the corrugator supercilli (above left eye) were recorded using the same Biopac hardware, gain settings and filters except for the EMG electrodes. Four EL 507 254S shielded silver chloride electrodes with disposible collars replaced the EL504 1" disposable cloth electrodes.

A Panasonic Colour CCTV camera (model WV-CL350/B) and a Panasonic DVD recorder (model DMR-ES15), positioned behind but above the monitor displaying the IAPS pictures, projected an image of the participant's face in the centre of a second monitor placed outside the participant's field of vision and provided a continuous recording of facial behaviour.

1.2.4. Procedure

Prior to arriving at the laboratory, participants had been interviewed, fully informed of the experimental requirements and had completed checks for potential ethical and experimental suitablility (Appendix 7). All selected participants then completed Spielberger's Trait Anxiety Questionnaire (Spielberger, 1983).

On arriving at the laboratory, participants read the information sheet that again described the study, were reminded of the procedure and then gave written informed consent to participate. Once seated in front of the computer, electrodes were attached and equipment and waveforms checked. The first practice session then began and was followed by experimental blocks 2-5 (or 7-10 depending on the sequence of conditions). The second practice session was then followed by Blocks 7-10 (or 2-5) and then a set of positive 'Feel Good' pictures to create a positive mind set with which to end the computer session.

Before removing the electrodes, Spielberger's State Anxiety Questionnaire and the recognition memory task were completed as in experiment 1. The electrodes were then removed and post-experimental questions asked to record participants experience of the study (particularly whether or not they believed that they were able to stop their emotional responses to the pictures).

As in experiment 1, the recognition memory task required participants to look at the set of printed pictures placed in front of them to see if they recognised any picture as having been in the experimental study they had just completed. They were instructed to leave blank any picture that they didn't recognise and to write the letter R in the centre of a picture they *remembered* (i.e. a picture they could remember coming up on the screen, or a picture they remembered focusing on a particular part of , or a thought they remembered having when viewing a particular picture), a K if they *knew* they had seen the picture but for which they could find no mental 'evidence' to support the feeling, and an F if a picture was accompanied only by a feeling of *familiarity.*

1.2.5. Results

A 2x2x2 within subjects ANOVA statistical test was used to analyse the results. As in experiment 1, results were analysed in three categories: physiological responses (HR, EMG), experiential responses (self-reported arousal ratings), and cognitive responses (the recognition memory task). Change scores were computed from raw physiological data, converted to z scores and then analysed. HR and EMG responses to fear, disgust, sad and mixed category pictures were tested using a repeated measures 2 x 4 ANOVA with two levels of Instruction (i.e. Feel and No Feel) and four levels of Emotion (i.e. fear, disgust, sadness and mixed). For HR, there was no main effect of emotion ($F_{3,93} = 1.6$ $p > .05$). For EMG corrugator activity, however, there was a main effect of emotion ($F_{3,93} = 6.33$ $p < .05$ $d = .17$) with a significant difference between responses to pictures inducing fear and disgust ($F_{1,31} = 12.47$p $< .01$ $d = .29$). More facial EMG activity accompanied pictures that induced feelings of disgust than fear (Means and SEs = -.084 (.06); .221 (.05) respectively). Comparisons of simple effects between fear and sadness, disgust and sadness, disgust and mixed feelings, and sadness and mixed feelings found no significant differences ($F_{1,31} = 3.86$ $p > .05$; $F<1$; $F_{1,31} = 1.07$ $p > .05$; $F_{1,31} = 2.48$ $p > .05$). Since all pictures were fully counterbalanced and there was no main effect of instruction ($F<1$) and no Instruction x Emotion interaction ($F<1$), there was no evidence that collapsing all negative pictures into a single negative category was masking different results.

1.2.5.1. Physiological Responses

A main effect of valence for HR responses ($F_{1,31}$ = 4.50 p < 0.03 d =.127) as expected, showed change scores with a fall in mean HR for negative pictures but a rise for neutral pictures. Mean changes and standard errors were -.06 (.03).for negative pictures and 06 (.03) for neutral pictures. However, there was no main effect of repetition (F<1) and no main effect of instruction (F<1). A t-test to see if the valence effect may have been confounded by fear and disgust responses analysed together in the negative category, showed no significant difference between the two emotions (t=.379 df31 p>.05). Electromyographic corrugator supercilii responses showed a main effect of valence ($F_{1,31}$ = 41.75 p < 0.001 d =.57) with a significant increase in activity during negative picture presentations and a fall during neutral picture displays. Mean change responses and SEs were .18 (.03) and -.18 (.03) respectively.

Table 13: Mean Change Scores (µV) and Standard Errors for EMG corrugator supercilii activity to negative and neutral pictures in the Feel and No Feel conditions

	Neutral		Negative	
	Mean	SE	Mean	SE
Feel	-.129	.037	.398	.067
No Feel	-.229	.043	-.042	.046

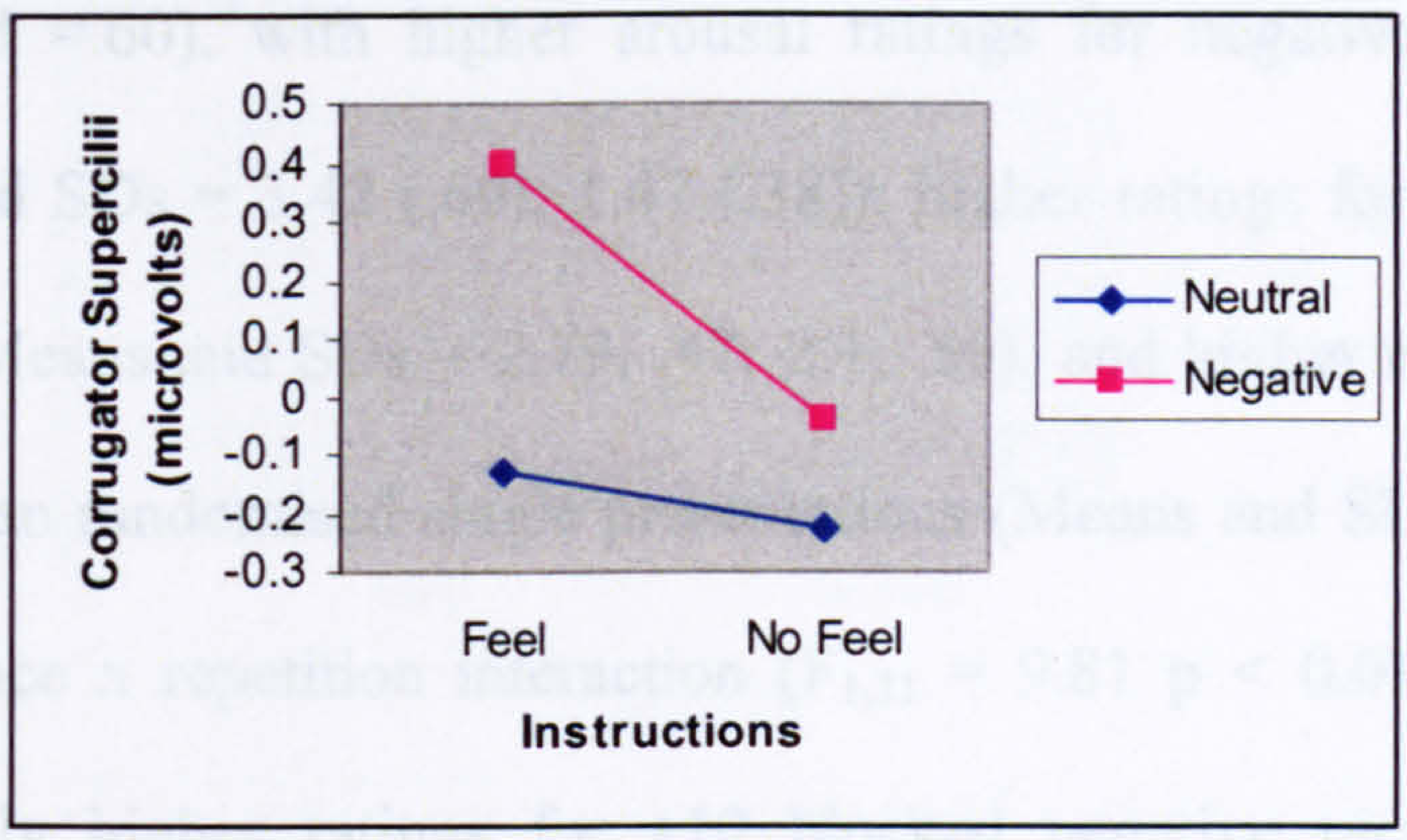


Figure12: EMG corrugator supercilii activity during Negative and Neutral picture displays in the Feel and No Feel conditions

A main effect of repetition ($F_{1,31}$ = 17.54 p < 0.001 d =.36) showed a fall in activity in the randomised single presentations but a rise for the x10 blocked single valence condition. Mean changes and standard errors (in parentheses) were -.10 (.02) and .09 (.02). There was also a main effect of instruction ($F_{1,31}$ = 20.83 p < 0.001 d =.40) with higher levels of activity in the Feel condition than the No Feel condition. Mean changes and standard errors were .14 (.03) and -.14 (.03). A significant Valence x Instruction interaction ($F_{1,31}$ = 9.14 p < 0.01 d =.23), indicated lower levels of corrugator activity for neutral pictures in both the Feel and NoFeel conditions but higher levels for negative pictures in the Feel condition (see Figure 12). Table 13 reports the exact means for the Valence x Instruction interaction.

Observation of the video recordings confirmed that participants maintained attention on all experimental pictures for the full 6 second presentation time and continued to focus on the inter-stimulus fixation cross throughout the study.

1.2.5.2. Arousal Ratings

As in experiment 1, there was a main effect of valence ($F_{1,31}$ = 487.82 p < 0.001 d =.94), instruction ($F_{1,31}$ = 126.63 p < 0.001 d =.80) and repetition ($F_{1,31}$ =

46.93 $p < 0.001$ d =.60), with higher arousal ratings for negative than neutral pictures (Means and SDs = 3.42 (.60); 1.47 (.38)), higher ratings for Feel than No Feel instructions (Means and SDs = 2.79, .47; 2.1, .50), and higher ratings for x10 blocked pictures than randomised single presentations (Means and SDs = 2.55, .48; 2.34, .50). A valence x repetition interaction ($F_{1,31} = 9.81$ $p < 0.01$ d =.24) also showed significantly higher ratings for x10 blocked negative pictures than x1 randomised negative pictures (Means and SEs = 3.58, .09; 3.26, .09) and no significant difference for neutral pictures (Means and SEs = 1.42, .05; 1.52, .06) as would be expected (see Figure 13).

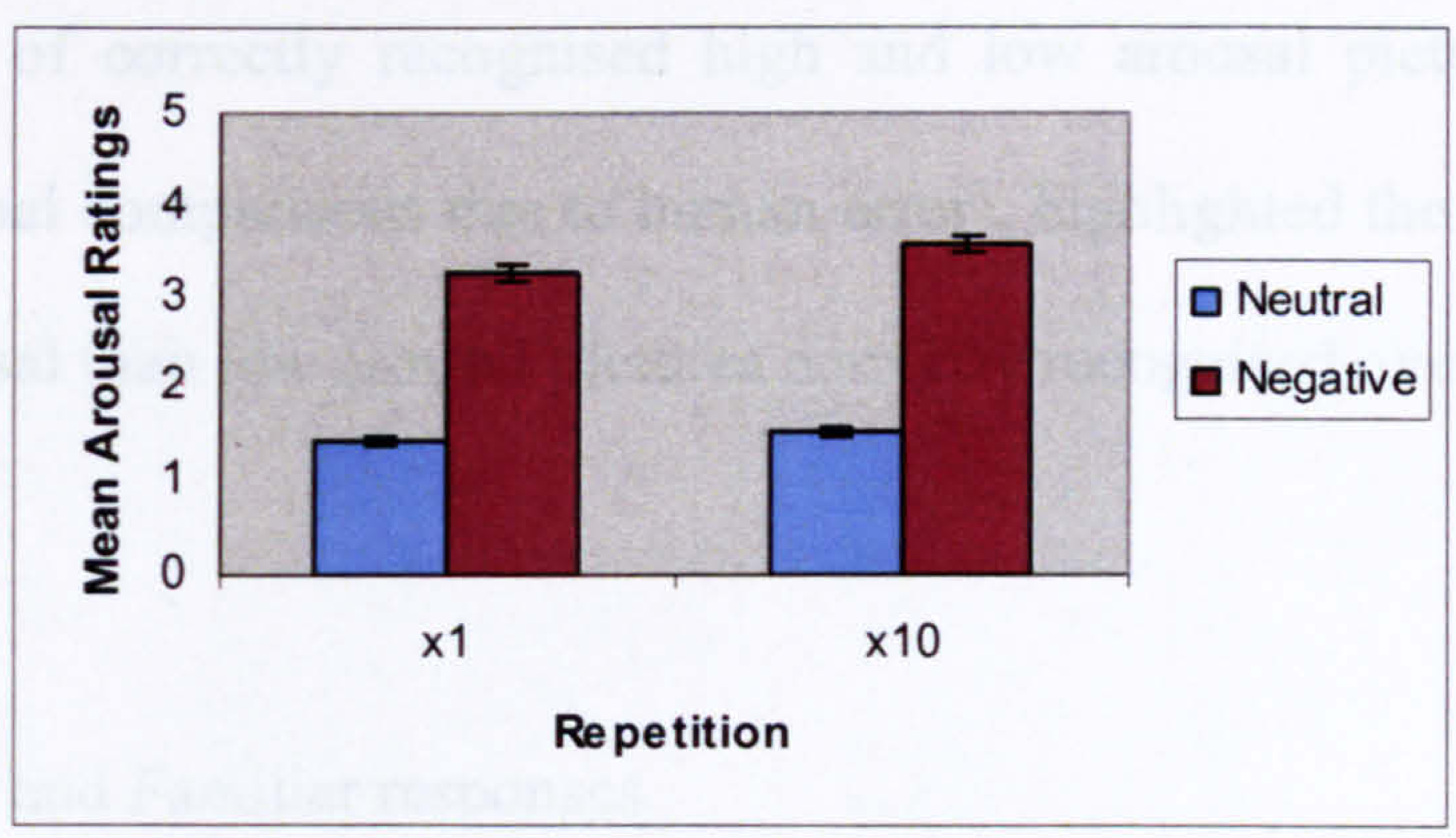


Figure13: Arousal ratings in the single randomised and blocked series conditions.

A significant Valence x Instruction interaction ($F_{1,31} = 44 .57$ $p < 0.001$ d =.59) for self reported arousal ratings also showed significantly higher ratings for negative pictures in the Feel than the No Feel condition (Means and SEs = 3.97,.08; 2.87, .12) and no significant difference for neutral pictures in the two conditions (Means and SEs =1.61,.07; 1.33,.05) (see Figure 14).

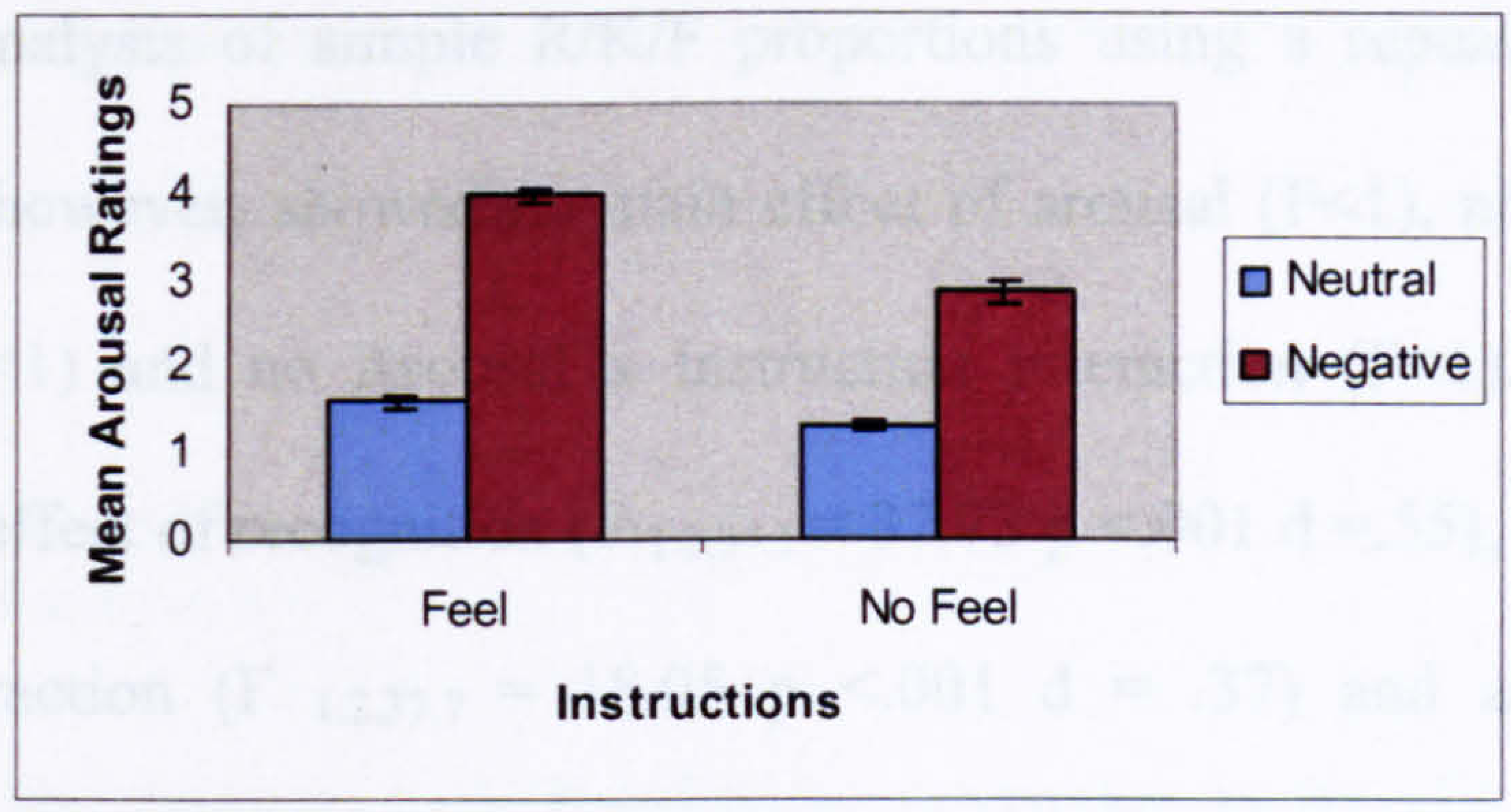


Figure 14: Arousal ratings for Negative and Neutral pictures in the Feel and No Feel conditions

1.2.5.3. Recognition Memory

An analysis of correctly recognised high and low arousal pictures, (though without proportional comparisons due to human error), highlighted the usual pattern of more high arousal than low arousal pictures correctly recognised overall.

Remember, Know and Familiar responses

Analysis of simple proportions by arousal, instruction and recognition responses showed the tendency for more high arousal than low arousal pictures to be Remembered than recognised with reported Know or Familiar responses (see Table 14).

Table 14 Mean proportions for R/K/F responses to negative and neutral pictures in the Feel and No Feel conditions

	Feel			No Feel		
Arousal	Remember	Know	Familiar	Remember	Know	Familiar
High	.58	.14	.09	.59	.12	.08
Low	.41	.27	.09	.37	.27	.12

Statistical analysis of simple R/K/F proportions using a repeated measures 2x2x3 ANOVA, however, showed no main effect of arousal (F<1), no main effect of instruction (F<1) and no Arousal x Instruction interaction (F<1). There was, however, a main effect of recognition ($F_{1.2,37.1} = 37.73$ $p < .001$ $d = .55$), an Arousal x Recognition interaction ($F_{1.2,37.7} = 18.05$ $p < .001$ $d = .37$) and an Arousal x Instruction x Recognition interaction ($F_{1.6,50.6} = 3.20$ $p = .05$). Once again, more high arousal than low arousal pictures were remembered (Means and S.E.s = .59 (.04); .39 (.05) and more Know responses were produced to neutral than negative pictures (Means and S.E.s: =.27 (9.04); .12 (.02);) (see Figure 15).

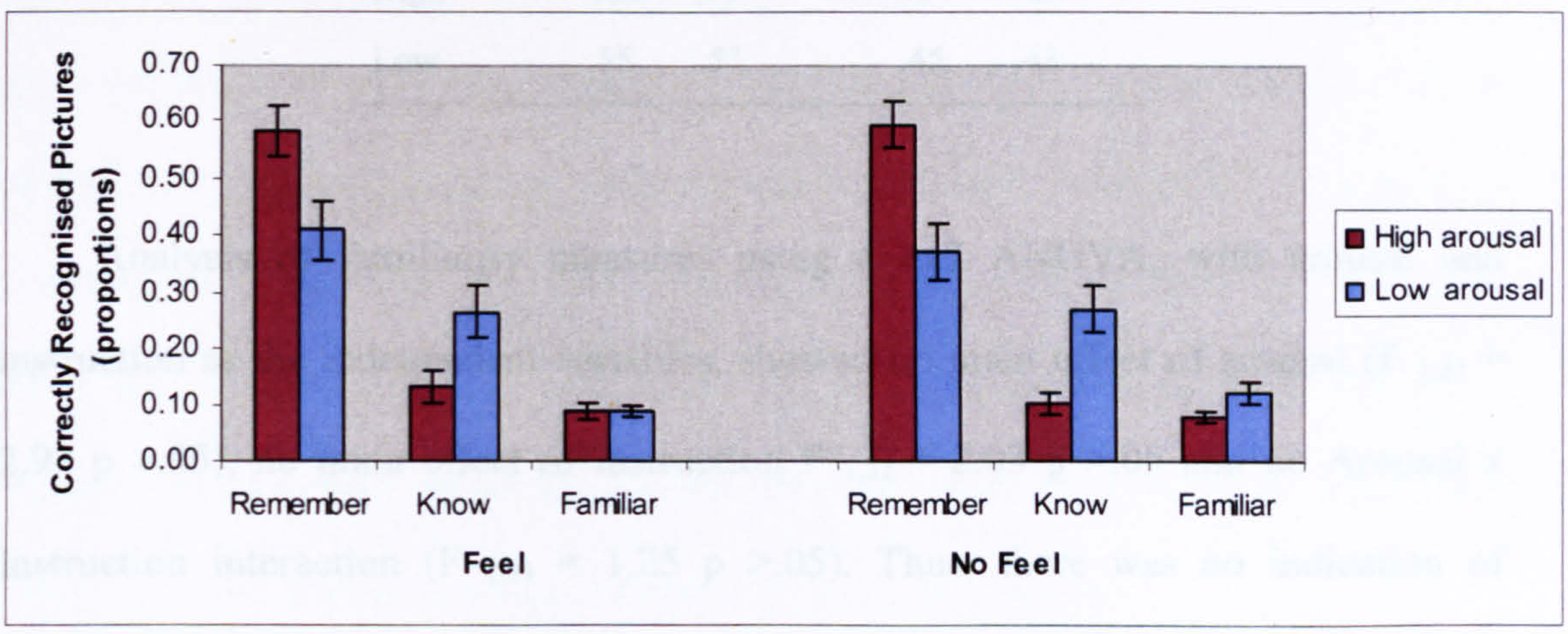


Figure 15: Recognition responses for high and low arousal pictures in the Feel and No Feel conditions

Comparison of both picture types, however, shows a smaller overall significant difference between remembered high arousal and low arousal pictures in the Feel condition ($F_{1,31} = 13.59$ $p < 0.01$ $d = .31$) than in the No Feel condition ($F_{1,31} = 23.94$ $p < 0.001$ $d = .44$), a smaller difference again for pictures producing Know responses in the Feel condition ($F_{1,31} = 8.39$ $p < 0.01$ $d = .21$) than the No Feel condition ($F_{1,31} = 20.91$ $p < 0.001$ $d = .40$), and a non-significant difference in the Feel condition

($F<1$) but a significant difference in the No Feel condition ($F_{1,31} = 5.53$ $p < .05$ d =.15) for pictures producing Familiar responses.

Recollection and Familiarity

Computed recollection and familiarity measures again showed greater recollection for high arousal than low arousal pictures (see Table 15) and hence, conversely, greater familiarity for low arousal than high arousal pictures.

Table 15 Recollection and Familiarity as a function of arousal

	Recollection		Familiarity	
Arousal	Feel	No Feel	Feel	No Feel
High	.66	.71	.34	.29
Low	.55	.57	.45	.43

Analysis of familiarity measures using a 2x2 ANOVA, with arousal and instruction as the independent variables, showed no main effect of arousal ($F_{1,31} = 2.92$ $p >.05$), no main effect of instruction $F_{1,31} = 2.03$ $p >.05$ and no Arousal x Instruction interaction ($F_{1,31} = 1.25$ $p >.05$). Thus, there was no indication of significant differences in recollection and familiarity processes that may underlie correct recognition of high and low arousal pictures and no indication of any effect of instruction on such processes.

1.2.6. Discussion

As found in experiment 1, there was no evidence that conscious and intentional instruction modulated HR responses despite a similar main effect of instruction on self reported arousal ratings. Conscious and intentional control of facial EMG appeared likely, however, since the pattern of corrugator supercilli activity mirrors a similar pattern of consciously experienced decreases in arousal ratings for negative pictures in the No Feel condition. This could suggest that participants attempted to control their emotional responses by controlling facial expressions. This tends to support facial expression studies that demonstrate changes in facial muscle activity resulting in changed experiences of emotion (Strack *et al.*, 1988). The same result would also be true, however, if controlling emotions resulted in changes in facial expressions. Gross found that suppressing the expression of emotion (Gross, 2002, Gross and Levenson, 1997b, Richards and Gross, 2000) actually *increased* physiological responses such as HR and GSR and produced a cognitive cost in the form of impaired memory. In this study, there was no effect on HR or GSR and no apparent cost in recognition memory. In fact, the significant increase in the number of negative pictures recognised in the remember category in the No Feel condition compared with the Feel condition, was the exact opposite result to that predicted from the Gross experiments and the results in experiment 1. Perhaps, therefore, changes in corrugator supercilli activity was the result of attempts at controlling *emotions* rather than the result of controlling *facial expressions*.

Analysis of the memory performance data shows that the proportion of correctly recognised high arousal pictures was greater than the proportion of correctly recognised low arousal pictures but no difference in the proportions of correctly recognised high and low arousal pictures were found in the Feel and No Feel conditions. However, there was a difference in the recognition data. This time the proportion of high to low arousal pictures remembered in the No Feel condition was *larger* than in the Feel condition suggesting an enhanced effect of emotional responses in recognition memory. In addition, this effect occurred *despite* a dampening of corrugator supercilli activity in the No Feel condition.

One concern is that none of the measures of emotion used so far has tapped into amygdala activity. As outlined in chapter 1, the amygdala is a key mechanism in the generation of affect and will be responding differently to negative and neutral pictures. However, corrugator supercilli activity is the only physiological measure that has produced significant differences in activity. It seems logical, therefore, to measure orbicularis oculi activity (i.e. the eyeblink response), a similar facial EMG measure but one that is also known to covary with amygadala activity. Since orbicularis oculi activity is automatically and unconsciously generated, this would provide a more sophisticated measure of affective responses and help disentangle responses due to conscious experience from responses that are the result of unconscious emotion generation.

However, there is still the problem of the differing effects of instruction in the two experiments. If executive functioning might be a factor, as previously suggested, then it may not be totally under conscious and intentional control. However the most plausible explanation for the two different effects lies in the nature of the experimental design. Whilst experiment 1 used a between subjects design, experiment 2 used a within subjects design. The fact that design was the major difference in the two experiments and that participants in experiment 2 were far less certain than were participants in experiment 1 that they had managed to control their emotional responses in the No Feel condition, suggests possible support for this explanation. In fact, experimental design, with an effect of instruction sequence, coupled with strategies employed to control emotional responses may offer a useful and coherent direction for further investigation.

In both experiments participants attempted to control their emotional responses in the No Feel condition by using a variety of strategies. The most frequently reported were, attempting to blur their vision, trying not to think, and viewing the pictures as film sets and therefore as unreal. A comparison of these strategies with those reported in the emotion literature, suggests that participants may have been attempting detachment, distraction and cognitive re-appraisal. The conflicting evidence found in the two experiments, however, suggests that distraction may have been *the most* influential since successful detachment and cognitive appraisal would be *more likely* to produce consistent results. For distraction, inconsistent results may be produced by the type of distractor items used. For example, since negative pictures in the Feel and No Feel conditions were taken from similar categories (e.g. dead bodies, accidents, mutilation, assaults) it is possible that the instruction *not* to feel responses in experiment 2 actually produced a response similar to the well documented 'white bear' effect (Wegner et al., 1987) which results in participants who are told not to think of a white bear finding it difficult to think of anything else. Participants in experiment 2 who undertook the Feel condition *before* the No Feel condition may well have been particularly vulnerable to this effect. If this was so, then participants in the No Feel condition in experiment 1, the between subjects design, may have found it easier to increase or decrease executive functioning by using distraction since they had no comparison condition which they were required to ignore. Participants who undertook the No Feel condition first in experiment 2, however, would be required to ignore the first Feel instruction in order to successfully apply the No Feel instruction, and this may have been difficult. Kahneman maintains that attention can be 'grabbed' by interesting or particularly self relevant stimuli (Kahneman, 1970). Thus, attention and executive functioning maybe 'hijacked' by stimuli irrespective of conscious control. However activated, it would seem that increasing or decreasing cognitive resources may be a factor worthy of further investigation.

1.2.7. Summary

Attenuated EMG corrugator supercilli activity in the No Feel condition, was interpreted as the result of a conscious attempt to control *emotions*, suggesting that conscious and intentional emotional control *may* change *some* physiological responses. In both experiments 1 and 2 the instruction to Feel and Not Feel emotional responses to negative and neutral pictures also had an effect in recognition memory. However, whilst the No Feel instruction appeared to dampen emotional responses in recognition memory in experiment 1, it appeared to enhance them in experiment 2. The results were very tentatively interpreted as a possible effect of attempts to modulate emotional responses by distraction as, depending on the type of distractor, the effect may be to enhance or attenuate emotional responses by increasing or decreasing attention to the attended stimulus. It was decided, therefore, to concentrate on distraction as a means of modulating emotional responses, even if indirectly via the manipulation of cognitive resources rather than via conscious control. Recognition memory data would continue to be taken but purely as a subsidiary activity for potential future research (see chapter 8).

Part II

Attenuated Emotion and Cognitive Resources

Chapter 4

Distraction

1.1. The Eyeblink Startle Reflex

1.1.1. Definition and Functions

The eyeblink startle reflex is a defensive reflex that functions primarily to protect the eye (Lane and Nadel, 2000). It is triggered in response to perception of a possibly harmful stimulus and is part of a much larger, whole body reflex that may be fully expressed if the aversive stimulus is sufficiently strong. In addition to the protective function of the blink itself, the reflex also serves to startle the individual, interrupt on-going behaviour and hence clear the mind of current information processing in order to leave mechanisms free to process information relevant to the aversive stimulus (Graham, 1979).

1.1.2. Elicitation and Measure of Affective Arousal

The eyeblink startle is believed to be the outcome of activation of a simple acoustic startle pathway involving three synapses: the cochlear root neurons, neurons in the reticular pontis caudalis, and facial motor neurons. Auditory input from the spiral ganglion cells in the retina is transmitted to the cochlear root neurons, embedded in the cochlear nerve. Lesions to the cochlear root neurons are known to attenuate the startle reflex in proportion to the number of neurons damaged and are, therefore, crucial to elicitation of the startle reflex (Lee et al., 1996). However, from the cochlear neurons, axons pass through the trapezoid body to the superior colliculus and, in addition, produce thick axon collaterals that terminate directly in the reticularis pontis caudalis (Davis, 1998).

The reticularis pontis caudalis is part of the reticular formation situated in the pons. More specifically, it is a medial column reticular nucleus located next to the reticularis tegmenti pontis and superior to the gigantocellular nucleus. It is a particularly important structure because axons from the cochlear root neurons terminate here at exactly the level that is critical for the continuation of the startle reflex onto cells that then project to motor neurons in the spinal cord (Davis, 1998). It is also crucial for its role in the affective modulation of the startle reflex (Davis, 1998, Davis et al., 1982, Miserendino and Davis, 1993, Lang et al., 1990).

As outlined in chapter 1, the amygdala is a major structure in the generation of emotional responses to external stimuli and in fear conditioning. It is also a major structure in the affective modulation of the acoustic startle reflex. Whilst sensory information passes from the sensory thalamus to the central and basolateral nuclei of the amygdala, projections from the central nucleus of the amygdala pass directly to the nucleus reticularis pontis caudalis (Rosen et al., 1991) forming a potential modulatory pathway (see Figure 16).

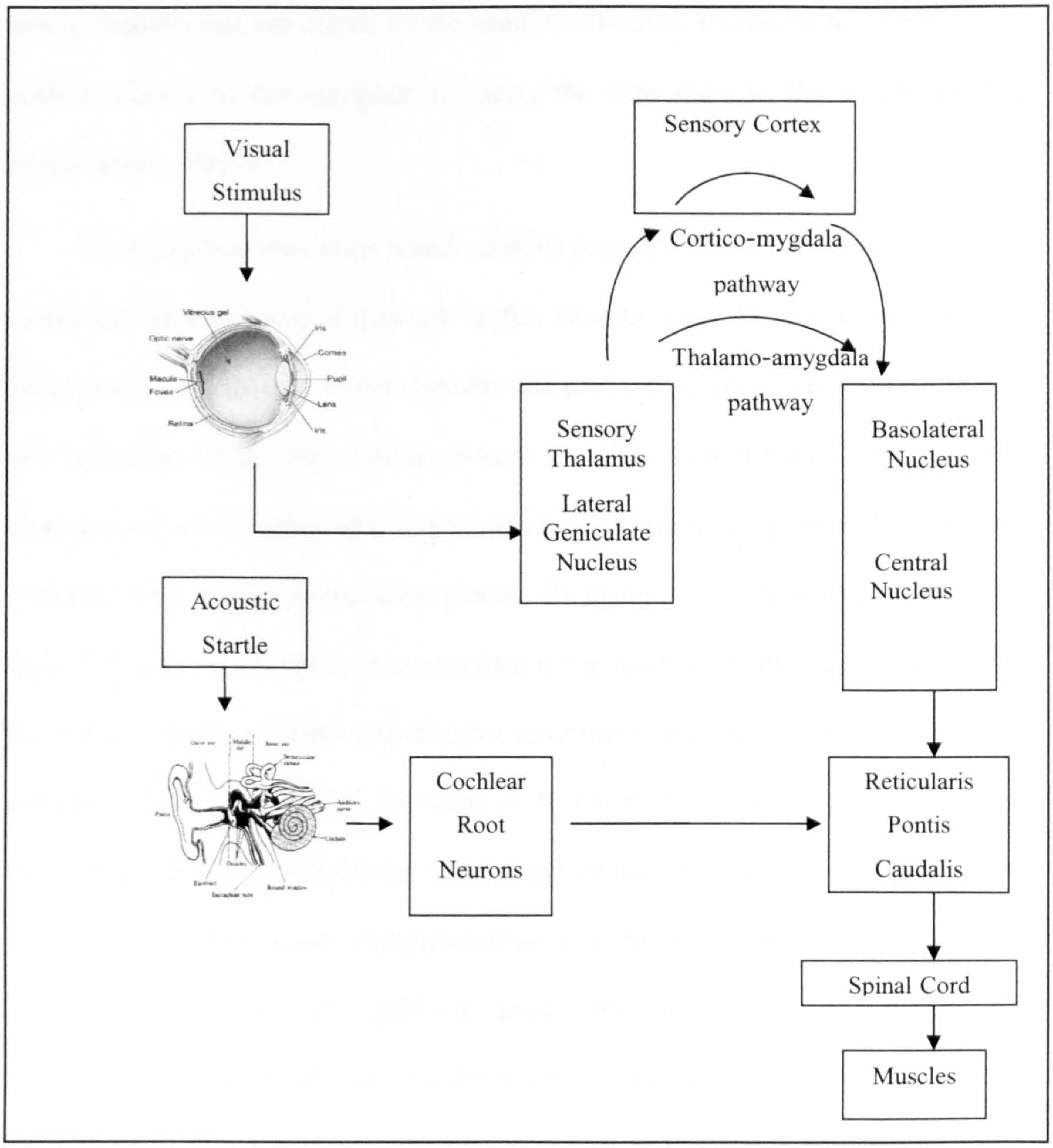


Figure 16: A schematic diagram of the fear and acoustic startle pathways

Evidence of the modulation of the startle by the amygdala is provided by Rosen and Davis (1988, p195) who state that the startle is an "extremely sensitive index of amygdala stimulation" because "low-level electrical stimulation of the amygdala (e.g. 40-400 μA, 25ms trains of 0.1ms square wave cathodal pulses) markedly increases acoustic startle amplitude". Supporting evidence is also provided by Koch and Ebert (1993) who demonstrated that electrical simulation of the central nucleus of the amygdala in rats increases the firing rate of the cells in the reticularis pontis caudalis that are driven by the auditory stimulus. Furthermore, lesions of the central nucleus of the amygdala eliminate the expression of the fear-potentiated startle (Davis, 1998).

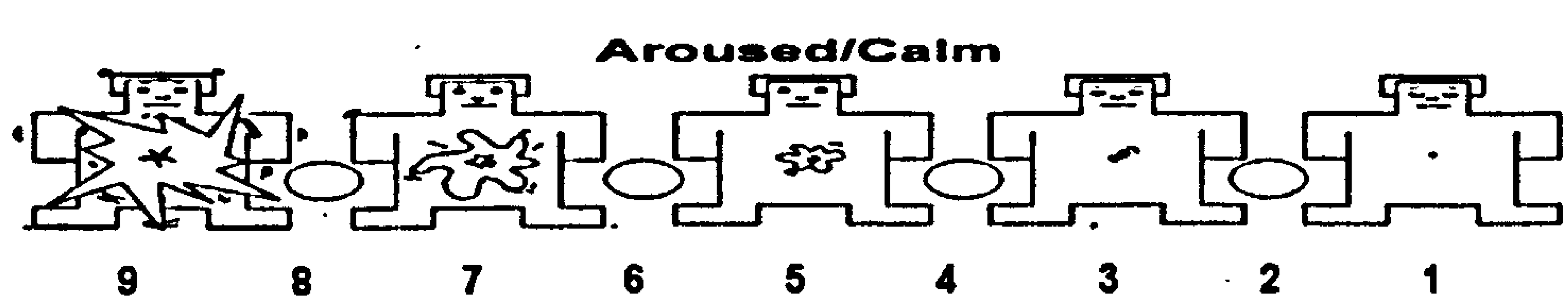
The amygdala-reticularis pontis caudalis connections are particularly important to psychologists because of their role in fear conditioning. When a stimulus that has been conditioned to an aversive stimulus that produces a fear response (i.e. a picture of a table fear conditioned with an electric shock) is viewed with a loud noise that produces the startle reflex, the magnitude of the startle reflex produced matches the intensity of the fear response to the picture. By manipulating the intensity of the fear response, it is also possible to manipulate the magnitude of the startle because the magnitude and speed of the startle reflex covaries with changing levels of amygdala activation. For psychologists, the value of the covariation lies in the provision of an easily accessible and measurable motor response (i.e. the eyeblink) that can be used to infer rather less accessible amygdaloid activity. Since the orbicularis oculi muscle is closest to the innervated pathway, facial electromyography (EMG) is usually selected to measure startle speeds and magnitudes (Bradley et al., 1999).

1.1.3. The Startle Reflex Paradigm

Development of the eyeblink startle programme is due largely to the work of Peter Lang and Margaret Bradley at the University of Florida. Within their perspective, emotions are defined as "atavars of primitive actions that evolved to ensure the survival of organisms" and developed from "tactical reactions to the context of aversive or appetitive stimulation" (Bradley et al, 1999 p. 248). They maintain that, via the process of natural selection, appetitive and aversive behaviours that ensured an animal's survival, became hard-wired into the neural system and gradually developed plasticity via subsequent associative learning. The accompanying motivational responses became the foundations of all modern emotions and can still be classified today along two fundamental dimensions: valence (pleasant – unpleasant) and arousal (low – high intensity). Valence is defined as a reference to the organism's "disposition to assume either an appetitive or defensive behavioural set" and arousal to the organism's disposition to "react with varying degrees of energy and force" (Bradley et al, 1999 p.264).

In order to study emotion, Lang and Bradley collected and tested pictures to form a picture bank of visual stimuli that would reliably evoke psychological and physiological reactions that would vary systematically over a range of expressed emotions (the International Affective Picture System: IAPs; Centre for the Study of Emotion and Attention, 1999). Pictures were viewed under laboratory conditions and physiological responses such as heart rate and skin conductance were compared with self assessment ratings of valence and arousal registered with the self-assessment manikin (SAM: Lang, 1980).

The self-assessment manikin provided a 9-point scale for judgements of valence with low scores denoting unpleasant pictures, and a similar scale for arousal with high scores denoting high levels of arousal (see Figure 17). Thus, unpleasant



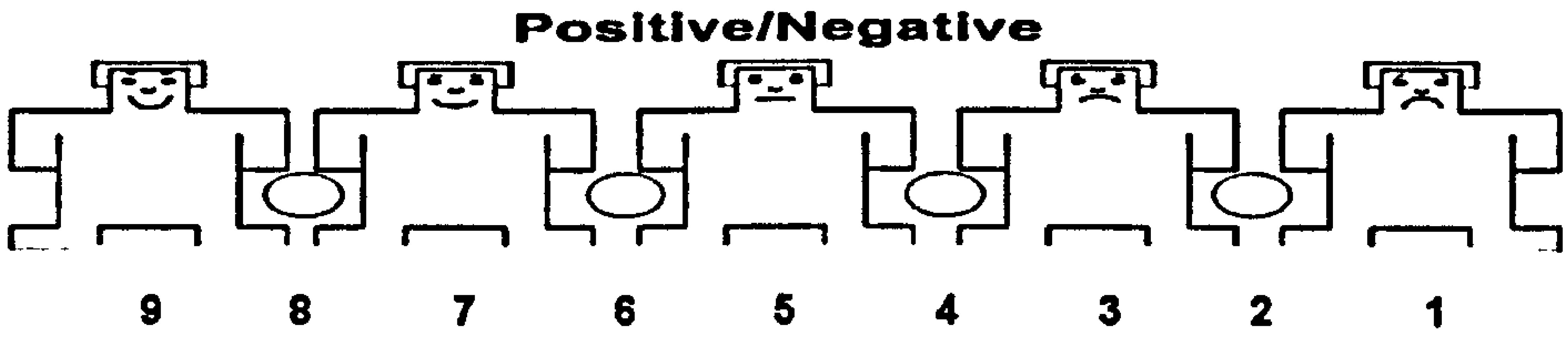


Figure 17: The self-assessment manikin (SAM:Lang,1980)

pictures were identified as having low valence and high arousal scores, pleasant pictures with high valence and high arousal scores and neutral pictures with moderate levels of valence and low levels of arousal.

When self-assessment ratings of valence and arousal were compared with physiological responses, it was found that arousal responses varied with valence. Heart rate responses decelerated in response to unpleasant pictures and the magnitude of skin conductance responses increased. Pleasant pictures produced accelerated heart rate and decreases in skin conductance responses. In fact, a decreasing trend was established for heart rate from pleasant > neutral > unpleasant pictures together with a corresponding increasing trend for skin conductance (Bradley et al., 1988).

With a set of valenced pictures validated by self-reported ratings and systematically varying physiological responses, the Lang laboratory could add the acoustic startle reflex, measure changes in orbicularis oculi activity, and thence infer changes in amygdala activity as a function of picture valence. The affective modulation of the startle reflex was demonstrated by the differences in response when an aversive startle probe initiated a reflex whilst participants viewed pleasant, unpleasant and neutral pictures. When viewing unpleasant pictures, the startle response was enhanced compared with neutral pictures and when viewing pleasant pictures it was attenuated (Bradley et al., 1990, Cuthbert et al., 1996). These responses were also checked against known physiological responses that showed decelerated heart rate and increased skin conductance during presentations of unpleasant pictures: responses that were not, therefore, due to a picture avoidance strategy (Bradley et al., 1988, Cuthbert et al., 1996).

Subsequent research that tested the validity of the paradigm established changes in arousal due to picture valence rather than the general arousal level of the individual (Bradley et al., 1988, Bradley et al., 1990), ruled out arousal changes to attentional demands such as focus of attention and interest (Vrana and Lang, 1988) and decreases in arousal due to the withdrawal of cognitive resources to the startle pathway when startle probe and picture modalities mismatched (Bradley et al., 1988, Bradley et al., 1999b, Bradley et al., 1990). Current studies of emotion regulation using fMRI, have also validated use of the paradigm to infer amygdala activity (Jackson et al., 2000, Ochsner et al., 2002, Ochsner et al., 2004) but have since raised questions about the primacy of the valence dimension over arousal (Dillon and LaBar, 2005), and the believed automatic and unconscious nature of amygdala activation (Jackson et al., 2000, Ochsner et al., 2002, Ochsner et al., 2004).

1.1.3.1. Automaticity

The automatic nature of the startle reflex is a particularly important debate because the startle is used as an indirect measure of automatic and unconscious emotion generation. fMRI studies by Ochsner and Jackson that have modulated amygdala activation with conscious emotion regulation instructions to enhance, maintain and suppress responses to valenced pictures, challenge traditional beliefs in automatically generated emotional responses. If amygdala activation is not automatic, then neither is the acoustic startle as a measure of automaticity. Though the orbicularis oculi muscle responds automatically to a loud noise producing the startle reflex, the startle response is modulated by the amygdala and the amygdala can be modulated by cortical processes. Thus, the startle response can be indirectly regulated and may be more useful as a measure of emotion regulation, therefore, than a measure of emotion generation.

Another form of indirect control is also possible via associative conditioning. Since the context and the stimulus to which the eyeblink is associated may be consciously selected by an individual, as in an experiment, or by society through learning and culture, the motor response may be automatic but the conditions that elicit it may not be. In fact, it suggests that automatically generated emotions may be limited to a few reflexes generated by the thalamo-amygdala pathway, and that the majority may be responses to cognitively learned associations and on-going cognitive re-appraisals. Of course, when learned associations generate emotional responses, the activation of the association may well be automatic and the attached valence may then be said to be automatically generated. However, it is still the automatic generation of a *learned* response that is made available for cognitive re-appraisal.

In an effort to be scientifically precise, definitions of emotion and automatic processing have become theory dependent. The result is a self-constructed problem in which the main difficulty becomes largely a question of temporal focus and semantics i.e. the difference between the generation of an early automatic and biologically determined reflex, and a later automatically elicited socially learned association. Ultimately, it is possible to view all affective responses as the products of original reflexes. However, what appears to be more important in the literature, is not *what* is being generated but *where* and *when.* If emotion is perceived as a process of which affect modulation is a part, then most of the difficulties are resolved. The initial stage may be a pre-attentive, automatic biologically determined process involving the thalamo-amygdala pathway. The next, though possibly occuring in parallel, may be a pre-conscious cognitive template matching process that activates affective responses via association and the cortico-amygdala pathway. The final stage may be higher order cognitive appraisals that interpret and evaluate stimuli for self relevance and desired goals. As the process unfolds, so early affect may initiate positive or negative appraisals that may finally give rise to more sophisticated discrete feelings. A similar though more detailed argument is made by Kappas in his article that seeks to reconcile differences in the work of Magda Arnold and Robert Zajonc (Kappas, 2006).

1.1.3.2. Consciousness

Linked to the debate on automaticity is also the problem of consciousness. Primary, biologically determined automatic reflexes generated via the thalamo-amygdala pathway may be evoked with pre-attentive perceptual processing (Cuthbert et al., 1996). However, secondary or conditioned reflexes may require conscious attention to match mental representations of external stimuli and trigger recall of associated affective responses. Cognitive re-appraisals of external stimuli certainly do require conscious attention and have been shown to respond to consciously attended instructions (Jackson et al., 2000, Ochsner et al., 2002, Ochsner et al., 2004). Perhaps, once again, the debate should not pose a dichotomy between conscious and unconscious processing, but concentrate on where, when and why consciousness is required. As previously stated (see Chapter1), pre-pulse inhibition may be the process by which the amygdala primes sensory processing and it may be that consciousness is required when complex processing of a stimulus is required. Baars (Baars and Franklin, 2003) suggests that consciousness is necessary to recruit higher order cognitive processing to interpret and evaluate stimuli. It is also interesting that during reward-punishment learning, (the basis of instrumental learning), monkeys require visual sightings of rewarded stimuli to make the correct behavioural choices. It has been found, for example, that amygdalalectomised monkeys are impaired on discrimination tasks for rewards that cannot be seen (Bayliss & Gaff, 1991; Gaff 1992). It might be that visual processing is also required during recall of associated visual stimuli.

1.1.3.3. Reliability

Since the magnitude of the eyeblink startle covaries with amygdala activation, the reliability of the startle as a measure of amygdaloid activity is high. However, the resistance of the affective modulation property to habituation is another advantage. Although the eyeblink itself habituates to repeated presentations of the same stimulus, as evidenced by the decreasing startle magnitudes, the affect modulation pathway is unaffected i.e. the magnitudes of the eyeblinks decrease overall but continue to vary systematically with affective valence (Bradley et al., 1993b). This is a highly desirable property since the effects of habituation cannot be confounded with the effects of affect modualtion. In addition, when the startle does habituate, it dishabituates extremely quickly making it an attractive measure for experimental designs with repeated trials. Finally, the independent nature of the eyeblink startle is another advantage because although the eyeblink is a clearly defined and measurable response, it produces little, if any, interference with on-going tasks. As summarised by Bradley "the startle reflex is modulated by the valence of on-going affective responses, independent of probe modality and regardless of whether the foreground content is perceptual or imaginal" (Bradley et al., 1999b).

1.1.3.4. Summary

The eyeblink startle reflex is an unconsious and automatic response to aversive stimuli processed via the thalamo-amygdala pathway. It may also be a response to less automatic and more consciously constructed cognitions processed via the cortico-amygdala pathway and acquired via learning and culture. Such cognitions may be activated during cognitive appraisals of external stimuli in order to match associated mental representations in long term memory and generate associated affect. In addition, it may be indirectly influenced by the regulation of attention controlled by the amygdala via sensory priming, and by the conscious selection of competing appraisals. It is particularly important to psychologists because it is believed to offer a measure of affective arousal via inferred measures of amygdala activation and can be used relatively easily in experiments designed to investigate affective responses to valenced visual stimuli.

1.1.4. The Eyeblink Startle Reflex and Distraction

Under normal conditions, the startle reflex is a part of an automatic emotional response and functions to orient attention to a highly relevant, important possibly life-threatening stimulus that requires a large input of processing resources. In the experimental situation, however, it is used as a measure of the intensity of the affective response to an attended stimulus. It can be used in this way because, as outlined above, the magnitude of the eyeblink reflex varies with the nature of the attended stimulus and covaries with the generated affective response. Thus, when an acoustic trigger is paired with a neutral picture, the magnitude of the resulting eyeblink is relatively small, indicating low level amygdala activity. When paired with a negative picture, however, the eyeblink is much larger, indicating higher levels of amygdala activity. As a result, the startle magnitude, can be used as a measure of the intensity of an affective response to an attended stimulus.

The purpose of the following experiments is to investigate the ability of distraction (as defined on page 88) to regulate emotional responses to negative stimuli by dampening responses at encoding and in recognition memory. Ochsner's evidence that demonstrates the ability of the MPFC to modulate amygdala in response to the outcomes of cortical appraisals (Ochsner et al., 2002), opens up the possibilities of cortical influences more generally on emotion processing. It is possible, for example, that if cognitive appraisal can modulate affective responses to stimuli, it may also be involved in generating them, as cognitive appraisal theorists have always maintained. Manipulating cognitive resources, therefore, and measuring potential effects on the eyeblink startle reflex, should provide evidence of whether or not distraction can modulate affect. More specifically, it is hypothesised that if cognitive appraisal is required to generate affective responses to external stimuli, and cognitive resources are necessary for constructing appraisals, then reducing cognitive resources available for appraisals by introducing a concomitant distractor task will result in reduced amygdala activation and attenuated affective responses. Reductions in amygdala activity will be evidenced by reduced eyeblink startle magnitudes. Thus, it can be predicted that the magnitude of the eyeblink startle for negative pictures will be larger when no distractor items are present.

Chapter 5

Distraction and Cognitive Resources

Experiments 1 and 2 manipulated conscious and intentional control of feelings with the instructions 'Feel' and 'Don't Feel' emotional responses to negative and neutral pictures. The results showed an effect of instruction on both the experience of responses to pictures and the effects in recognition memory but the exact processes involved were unclear. The results, together with participant comments and a review of emotion regulation studies, suggested that the effects were most likely due to attempts at effortful distraction. It was decided, therefore, to investigate the effects of effortful distraction on the on-going process of emotion generation. A review of the eyeblink startle paradigm, summarised in the preceding chapter, suggested that emotion generation may involve a number of different processes including cognitive appraisals. Since the instructions manipulated in experiments 1 and 2 had an effect on the modulation of affect in recognition memory, however, it was decided to investigate the potential effect of effortful distraction on cognitive processing of attended stimuli.

Research investigating the effect of effortful distraction on antecedent and response focused emotion regulation strategies has demonstrated that it can attenuate emotional responses (Erk et al., 2006, Van Dillen and Koole, 2007) and is thought to do so by withdrawing cognitive resources, and hence cognitive processing, from the attended stimulus. Cognitive attentional resources are known to be necessary for amygdala activation during on-going *emotion generation*. Current debate, however, is focused on whether attentional resources can be pre-attentive or of necessity require conscious attention. Whilst Vuilleumier's results support traditional theories of unconscious and automatic emotion generation and hence pre-attentive processing (Vuilleumier, 2005, Vuilleumier et al., 2001a, Vuilleumier et al., 2001b), Pessoa's recent evidence suggests that conscious attention is obligatory (Pessoa et al., 2005a, Pessoa et al., 2002a, Pessoa et al., 2002b). In his studies, Pessoa maintains that the more difficult unattended tasks he uses take conscious attention away from the attended stimulus and reduce amygdala activation.

Another possible explanation for these results, however, which may also resolve the conflicting evidence produced by Vuilleumier and Pessoa, is that by utilizing difficult unattended tasks, Pessoa not only reduced *conscious* attention but *attentional resources per se,* and that it is the reduction in attentional resources per se that is crucial. If the unattended stimuli operate in a similar way as items in a distractor task, increasing the difficulty of the unattended stimuli would increase the reduction of attentional resources (Van Dillen and Koole, 2007) and attenuate emotional responses.

One way of testing this hypothesis is to run experiments in which participants are required to view negative and neutral pictures (as in Experiments 1 and 2) and hold in mind a distractor item whilst picture viewing in order to successfully complete a subsequent test to sample matching task. Occupying working memory in this way would reduce cognitive resources available for processing the pictures and attenuate emotional responses. Attenuation of emotional responses could be measured via the eyeblink startle reflex (see chapter 4).

Distraction tasks in these experiments would be slightly different from classical distraction tasks in that distractor items would be presented whilst the attended stimulus was still visually present. Maintaining visual attention with an instruction to view the pictures for the full presentation time, then enables the manipulation of *cognitive* resources rather than more specific *attentional* resources as in most classical distraction studies.

The specific research question that the following chapter attempts to address, therefore, is: Does distraction reduce cognitive resources during an on-going emotion generation process and attenuate emotional responses?

1.1. Experiment 3

1.1.1 Introduction

Studies of effortful distraction have concentrated on antecedent and response focused strategies of emotion regulation and have demonstrated that the withdrawal of cognitive resources from anticipation of a negative event can down-regulate negative emotion. In a recent fMRI study (Erk et al., 2006), graded distraction tasks were used during anticipation of subsequent negative emotions to investigate the effect of effortful distraction on emotional responses. During an anticipatory period that preceded presentation of negative and neutral IAPs pictures, participants were required to complete either an easy 0-back task requiring recognition of the number 3 or a more difficult 2-back matching test to sample task (i.e. a task requiring the matching of a current digit with a figure presented 2 slides previously and registering a same/different decision). Anticipation of the negative or neutral pictures was manipulated with either a 'frowny' or 'smiley' face. Results from the study showed that during picture presentation, there was a main effect of valence but not during the anticipatory period. During picture presentation, activation was observed in the right DLPFC, the left ventrolateral PFC, lateral amygdala and occipital, fusiform and superior parietal cortex. However, during the anticipatory period, a valence x cognitive load interaction showed greater activation in the anterior rostral part of the MPFC and right amygdala during the 0-back than the 2-back task preceding both picture types, but even greater activation during anticipation of negative than neutral pictures. The reduction in activation in the 2-back condition was interpreted as the result of a reduction in cognitive processing of the anticipated emotion due to the withdrawal of cognitive resources for the distractor tasks.

In a similar study, Van Dillen et al (Van Dillen and Koole, 2007), also manipulated cognitive load but did so *after* presentation of neutral and negative pictures and then investigated the effects of cognitive load on mood. In a series of 3 experiments, pictures that varied in affective intensity were first followed by a task no task manipulation, then a more or less demanding task, and finally by more or less demanding tasks that were expected or unexpected. The distractor tasks used were graded arithmetic equations involving simple addition or subtraction, or more complex multiplication or division. All tasks required a test to sample correct/incorrect decision judgement. Mood was manipulated by the negative and neutral pictures and was measured via self-reported mood ratings taken after the distractor task. Results from the study showed that negative moods were reduced by distractor tasks, and that more complex tasks produced greater reductions in negative mood than simple tasks. In addition, unexpected tasks (thought to place a higher cognitive load on working memory since no reliance could be placed on already active knowledge structures in long term memory) demonstrated yet further reductions. Taken together, the results from the three experiments suggest that the more cognitive resources withdrawn from negative mood maintenance, the less intense the mood becomes.

Both the Erk et al and the Van Dillen et al studies manipulated cognitive load with distractor tasks and concluded that a reduction in cognitive resources available for emotion processing results in modulated emotion. However, since both studies manipulated distraction as either an antecedent or response focused strategy, both manipulated 'thought' distraction before or after the negative event. In experiments 1 and 2 described in chapter 3, however, participants were believed to have attempted effortful distraction during an *on-going* emotion generating task i.e. to regulate their affective responses whilst continuing to view the affect generating stimuli: in effect, to stop processing. The aim of the following experiment, therefore, was to manipulate distraction during *on-going* emotion generation and look for evidence of affect modulation as a result of reduced cognitive processing of the concurrent task. It was hypothesised that when participants are engaged in a distractor task requiring maintenance of items in working memory in order to successfully complete a subsequent test to sample matching task, affect modulation will be down-regulated.

Much evidence now exists to show that significant differences in blink magnitudes occur when attention is focused on negative rather than neutral stimuli and that startle magnitudes are larger for negative than neutral stimuli (Lang et al, 1990; Bradley et al, 1993; Yartz et al, 2000; Carson et al, 2004) indicating greater amygdala activation. This known effect was used to measure an hypothesized effect of working memory by manipulating cognitive load, measuring startle magnitudes to valenced stimuli in no load and load conditions and comparing the results. Smaller startle magnitudes in the cognitive load condition would indicate attenuated emotional responses due to a loss of cognitive resources and cognitive processing.

Self-report arousal ratings are a commonly used measure of the experiential component of an emotion (Gross & Levenson, 1993; Lang et al, 1993; Scott, 1993). It was hypothesized that if working memory requires conscious attention, then manipulating the degree of conscious awareness of picture valences via the manipulation of cognitive load, and hence available attentional resources for picture processing, would produce main effects of both valence and cognitive load.

1.1.2. Participants

Twenty two participants (18 female: 4 male; Mean age = 20.59, SD = 3.39), all Leeds University undergraduates, took part in the study for course credits. Prior to selection, all participants completed the Centre for Epidemiological Studies Depression Scale (CES_D): a self-report depression scale for research in the general population (Radloff, L.S., 1977), and a demographic questionnaire, and all gave written informed consent.

1.1.3. Stimuli and Design

One hundred and twenty eight pictures (64 negative: 64 neutral) were selected from the International Affective Picture System (IAPS)(Lang, Bradley & Cuthbert, 1999) to generate emotional responses and arousal levels. Negative pictures were selected with low valence and high arousal ratings (Means: 2.52, 6.34): neutral pictures with average valence and low arousal ratings (5.17, 2.98). To form 2 blocks of pictures for the experimental conditions, equal numbers of each valence type were randomly assigned to each block, making 64 pictures per condition (32 negative: 32 neutral). Forty two of these (21 negative: 21 neutral) were randomly assigned to probed trials and 22 (11 negative: 11 neutral) to non-probed trials. Each picture was displayed on a computer screen for 5 seconds and was preceded by a white screen with a black fixation cross centered and displayed for 1000ms.

On probed trials, the startle reflex was triggered by a 50ms 100Db burst of white noise generated at intervals of 2.5, 3.5 and 4.5 seconds from picture onset. A seven-point rating scale was displayed following each picture to prompt participants to register self-reported arousal ratings. A standard 7-key response pad with keys labeled 0 – 6 registered responses ranging from 0, "I feel absolutely nothing at all" to 6, "I feel extremely strong emotions". The rating scale was displayed until a response was registered or to a maximum time of 2 seconds. No more than four pictures of the same valence were displayed consecutively. Both pictures and conditions were fully counterbalanced.

Four hundred and eighty faces were selected from 10 face databases and were made least verbalizable (i.e. constructed to eradicate distinguishing features in order make differences in the images difficult to identify and remember using language such as verbal descriptions and thereby encourage visual processing). Least verbalizable faces have been constructed and used by the Jha laboratory, University of Pennsylvania, and permission was given to use their faces. To supplement this resource, and with permission, faces from 9 other face databases were also appropriately cropped and airbrushed using Adobe software to make them least verbalizable (see Appendix 4). All images used, therefore, were full face, black and white photographs cropped to exclude all but facial features.

Size was controlled via the use of a plain white oval picture frame which became invisible on the computer screen. All faces, therefore, were exactly the same size and presented in the centre of the monitor. Faces were also matched for gender, race (e.g. Caucasian, Asian), physical features and image tones in the load condition to encourage visual processing. To ensure that working memory and not long term memory was activated, two separate face sets were constructed so that no image was used more than once in either condition and occurred in one condition only. Cognitive load and no load were manipulated via a gender decision task in the no load condition and a test to sample matching task in the cognitive load condition. Fifty percent of trials in the load condition contained matching faces and fifty percent non-matching faces.

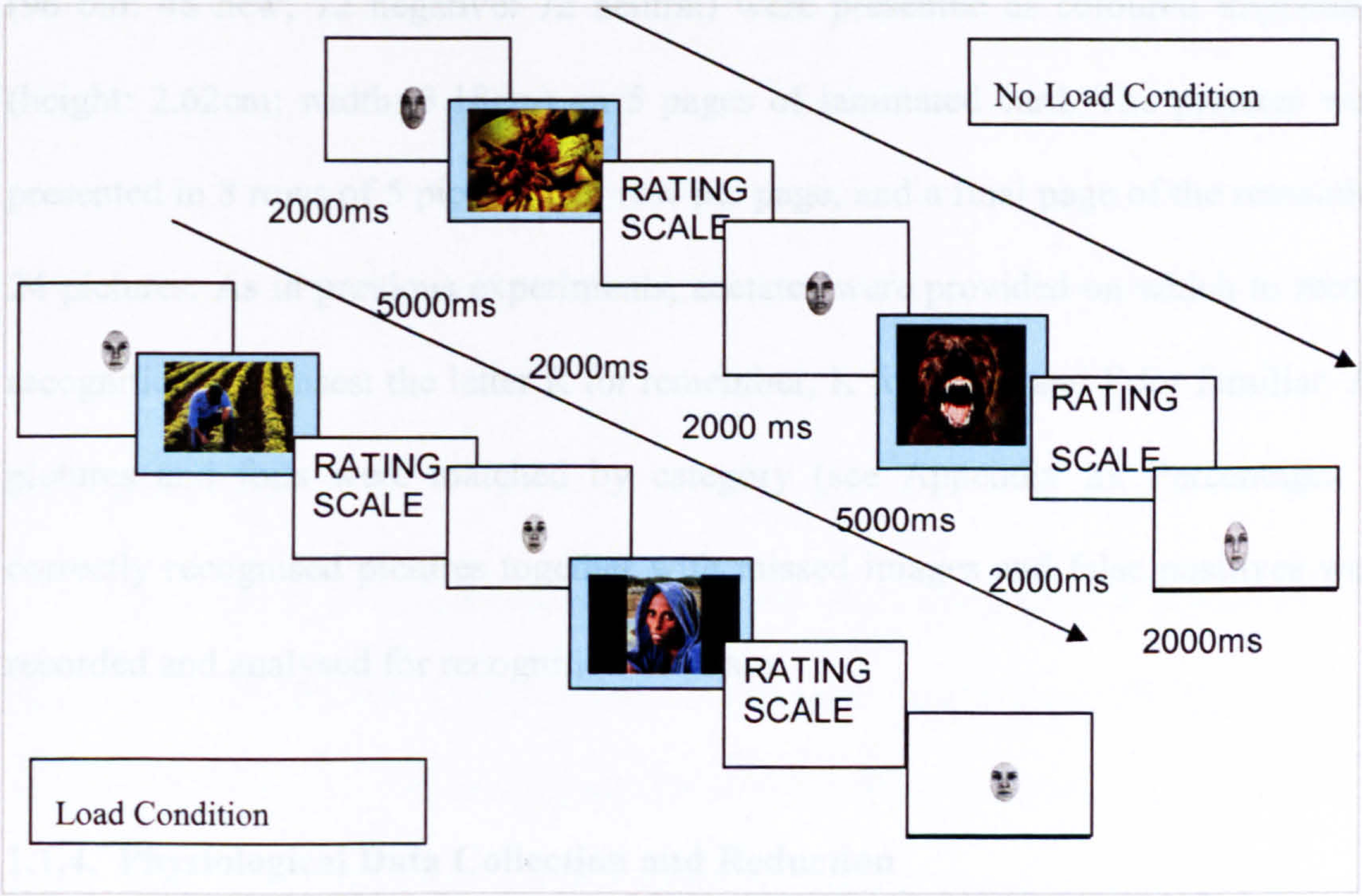


Figure 18: Presentation sequences for the load and no load conditions (see text for specifications)

Each trial consisted of 5 screens including a face, a picture and a rating scale and a screen with a fixation cross that preceded the faces and pictures (not shown in Figure 18). In the cognitive load condition the first face in the following trial was used for the matching task making the design a traditional 1-back (see Figure 18). Faces were centred, preceded by a 1000ms fixation cross and remained on the screen for 2 seconds. Pictures were presented as full screen images. The 64 trials in each condition (32 negative: 32 neutral) were divided into 3 blocks so that no block lasted longer than approximately 5 minutes. SuperlabPro software was used to create and run the computer programme and interfaced with a second computer that displayed a digital pulse alongside the orbicularis oculi waveform each time a picture was presented.

The recognition memory task consisted of one hundred and forty four pictures (96 old: 48 new; 72 negative: 72 neutral) were presented as coloured thumbnails (height: 2.62cm; width: 3.18cm) on 5 pages of laminated card. The pictures were presented in 8 rows of 5 pictures per row per page, and a final page of the remaining 24 pictures. As in previous experiments, acetates were provided on which to record recognition responses: the letter R for remember, K for know and F for familiar. All pictures and foils were matched by category (see Appendix 2). Percentages of correctly recognised pictures together with missed images and false positives were recorded and analysed for recognition accuracy.

1.1.4. Physiological Data Collection and Reduction

Raw electromyography (EMG) was recorded from the orbicularis oculi muscle beneath the left eye using 2 EL254S shielded electrodes and disposable adhesive collars following guidelines proposed by Fridlund and Cacioppo (2000). The skin was prepared and abraded following Blumenthal et al (2005). Electrodes were attached and the electromyographic activity routed through a Biopac MP150 system. The raw signal was amplified (Gain: 5000) and filtered (low pass filter: 500Hz; high pass filter: 10Hz) using a Biopac EMG 100C Electromyogram Amplifier Module and digitized using Acqknowledge Software. Eyeblink activity was rectified and integrated on-line following Biopac's own recommended procedures (Application Note AS214), sampled at 1000Hz and averaged over 50 samples. Sampling started just before the experimental block began and continued to the end (continuous recording). A digital pulse generated by the Superlab software marked a point on the waveform immediately prior to each startle probe onset. The eyeblink reflex was then measured for 350ms from this point.

The magnitude of the startle eyeblink reflex was measured using the Biopac peak-to-peak (P-P) function. This function computes the difference in microvolts between the highest and lowest peak in the selected time window and pastes the outcome in the system's journal. The raw data was then converted to z scores and entered into an SPSS database for analysis using a 2x2 repeated measures ANOVA.

1.1.5. Procedure

Upon arrival at the laboratory, participants read background information to the study, received detailed instructions of the experimental requirements and then gave written informed consent. Participants sat facing a computer screen approximately 1 metre away with a response pad resting on the knee to minimize hand movements. After attaching the electrodes, a short equipment test was followed by a practice session of the first task to ensure familiarity with task instructions and timing. When viewing the pictures, participants were instructed to look at the screen for the full 5 seconds and only register their response when the rating scale appeared on the screen. They were also instructed to register their first spontaneous response and think only of its strength not the valence (see Appendix 1).

In the cognitive load condition, participants were required to hold in mind a preceding face ready for the post-stimulus sample to test matching task. This was in order to activate and maintain working memory activity in order to reduce available resources for processing the pictures. They were also told to hold the picture in mind by visualizing the image in their heads and re-activating it when required to match it with the test face. This was done to avoid matching via familiarity rather than working memory. Responses to the face matching tasks were recorded using coloured keys on the response pad whilst the faces were on the screen. The first experimental condition was then completed, followed by the second practice session and the second experimental condition. The order of experimental conditions depended on counterbalanced sequences. A final set of 'Feel Good' pictures, as before, concluded the computer session.

Participants were then required to complete the recognition memory task. Five laminated sheets of coloured thumbnail sized pictures were placed one at a time on a table in front of the participant. The task was to look at the pictures to see if any were recognised as having been in the previous computer presented experimental conditions. Recognised pictures were labelled R for remember (i.e. if the participant actively remembered a picture appearing on the computer screen, or remembered focusing on a particular part of a picture, or remembered something they had thought about at the time), K if they *knew* thay had seen the picture but had only a feeling of knowing with no mental 'evidence' to support it, and F if they had just a feeling of familiarity so it probably was in the study. Unrecognised pictures were left blank. After the recognition memory task, the electrodes were removed and participants were asked about their experience of the study and strategies used to remember pictures in the in the cognitive load (i.e. the sample to test matching) condition.

1.1.6. Results

Analyses and results were limited to orbicularis oculi activity, arousal ratings and recognition memory data since these measures are the most salient for testing distractor effects.

1.1.6.1. Startle Magnitudes

Analysis of the results showed that there was no main effect of cognitive load ($F<1$), no significant main effect of valence ($F_{1,20}=1.64$ $p=.215$ $d=.08$) but a significant interaction between valence and cognitive load ($F_{1,20}=4.26$ $p=0.05$ $d=.18$). The interaction reflected that the effect of valence was significant only in the no load condition ($F_{1,20} = 5.04$ $p< .05$ $d=.20$), showing considerably higher startle magnitudes to negative than neutral pictures (Means and SEs (μV) = (neutral) -.0068, .513; (negative) .1319, .486). Valence was not significant in the cognitive load condition ($F<1$) (see Figure 19).

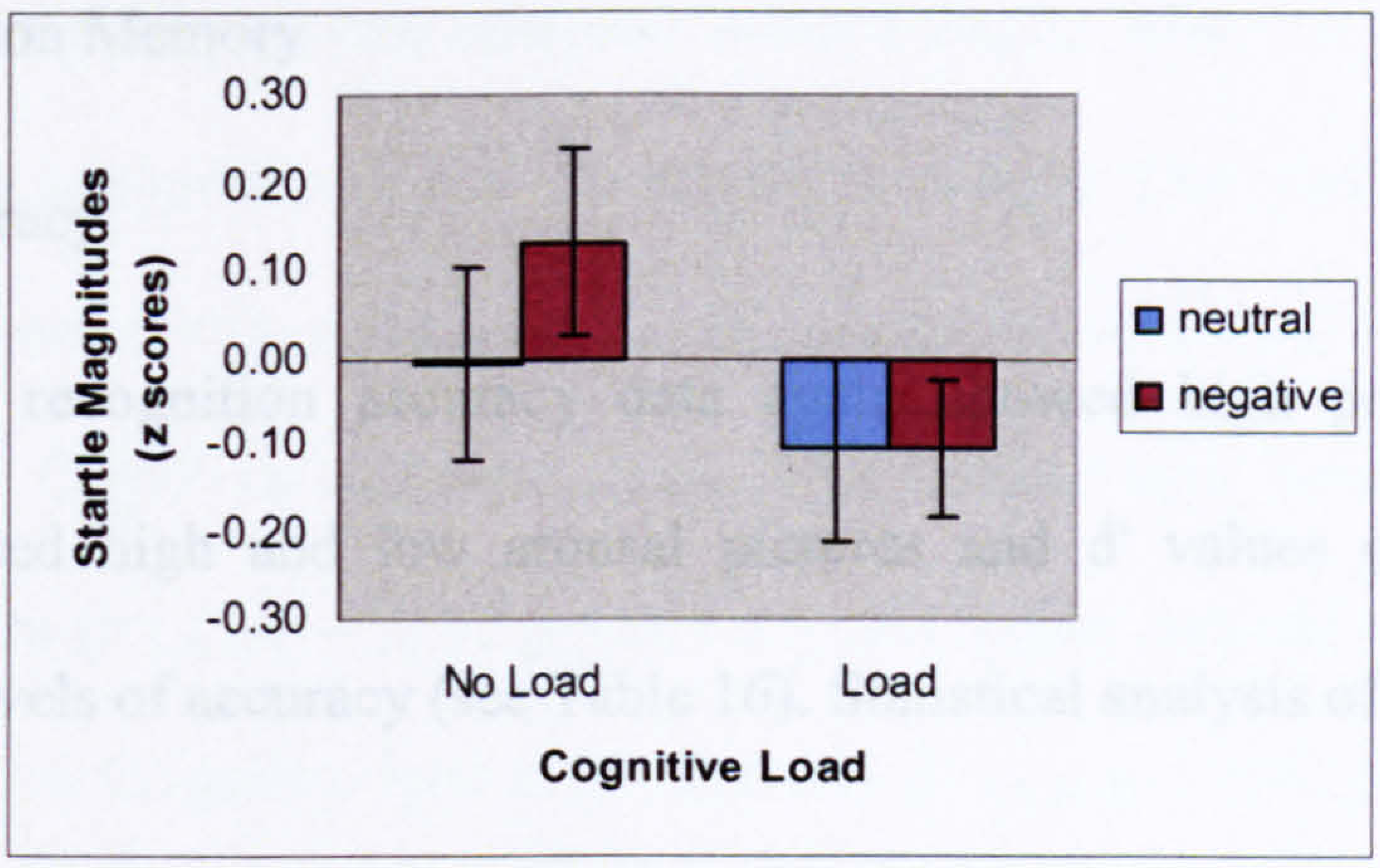


Figure 19: Startle responses to Negative and Neutral pictures in the No Load and Load conditions.

1.1.6.2. Arousal Ratings

As in experiment 1, for self-reported arousal ratings, there was a significant main effect of valence ($F_{1,21}$ =218.66 p<0.001 d=.91) and no main effect of cognitive load (F<1) and no Valence x Cognitive load interaction (F<1) (see Figure 20). Once more, there was no indication of a loss of conscious attention or a dampening of emotional awareness.

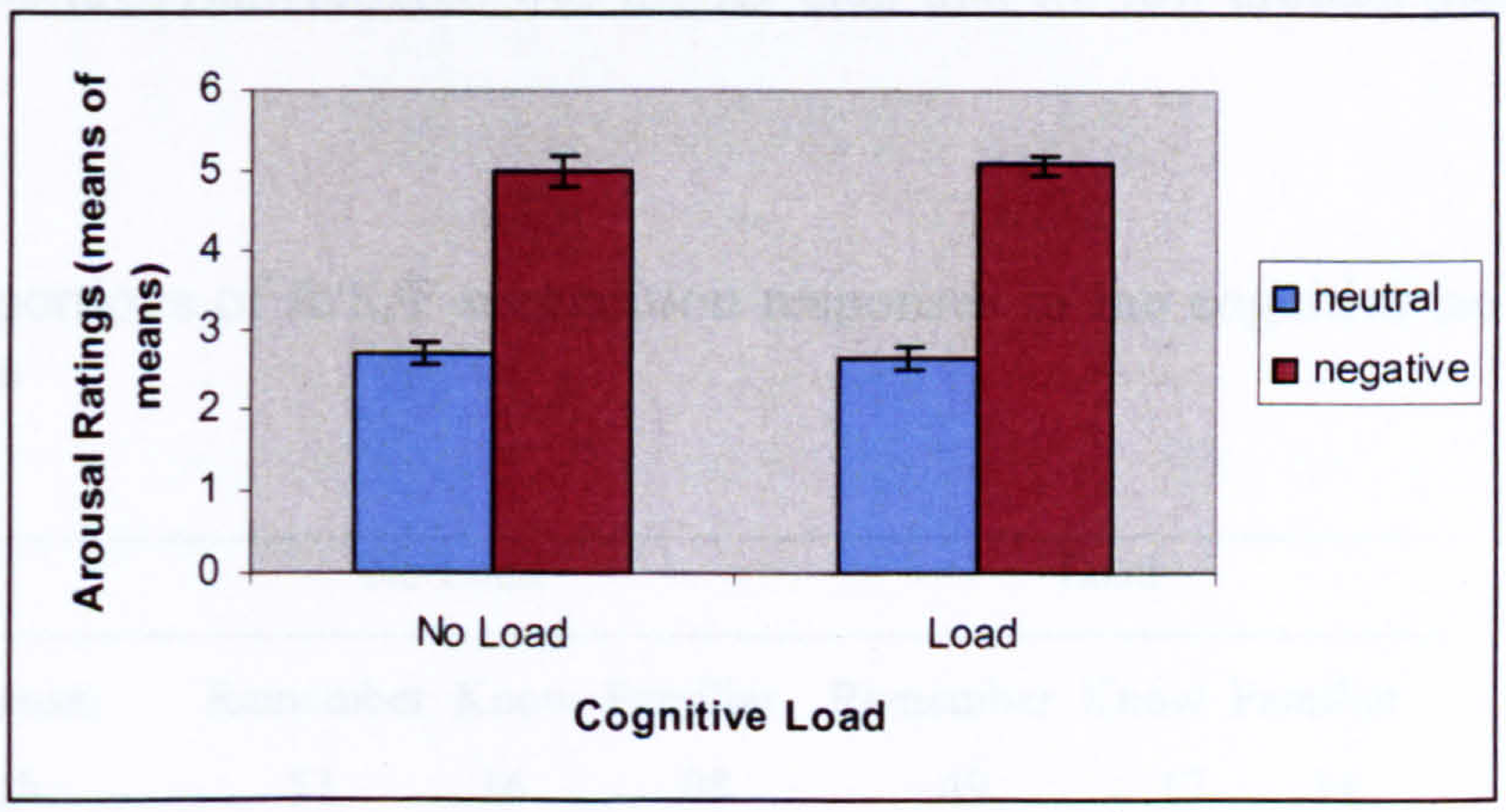


Figure 20: Self Report Arousal Ratings for Negatively and Neutrally valenced pictures in the two cognitive conditions.

1.1.6.3. Recognition Memory

Recognition Accuracy

Analysis of recognition accuracy data again showed high proportions of correctly recognised high and low arousal pictures and d' values of above 2.0 suggesting high levels of accuracy (see Table 16). Statistical analysis of recognition

Table 16. Recognition Accuracy as a function of Arousal

Arousal	Hits	FAs	d'
High	.77	.06	2.37
Low	.76	.02	2.59

accuracy showed that d' was significantly greater for low arousal than high arousal pictures (t = 1.83 df = 20 *p <.05).

Remember, Know and Familiar responses

Analyses of R/K/F responses showed that in both conditions, the proportion of high arousal pictures remembered was higher than that for low arousal pictures (see Table 17).

Table 17. Proportions of R/K/F recognition responses in the cognitive no load and load conditions

	No Load			Load		
Arousal	Remember	Know	Familiar	Remember	Know	Familiar
High	.53	.16	.08	.49	.17	.14
Low	.51	.14	.13	.48	.11	.11

All simple proportions were analysed using a 2x2x3 ANOVA with arousal, cognitive load and recognition as the independent variables. The results showed no main effect of arousal (F<1), no main effect of cognitive load ($F_{1,20} = 1.58$ $p > .05$) and no Arousal x Cognitive load interaction (F<1). There was, however, a main effect of recognition ($F_{1.4, 28.8} = 32.92$ $p < .001$ d = .62) but no Arousal x Recognition interaction (F<1), no Cognitive load x Recognition ($F_{1.6,31.5)} = 1.62$ $p > .05$) and no Arousal x Cognitive load x Recognition interaction (F<1). Analysis of the main effect of recognition showed a significantly higher proportion of Remember responses than either Know ($F_{1,20} = 30.90$ $p < .001$ d =.61) (Means and SEs =.50 (.05); .15 (.03) or Familiar ($F_{1,20} = 45.92$ $p < .001$ d =.70) (Means and SEs = .50 (.05); .12 (.02). There were no significant differences between proportions of Know and Familiar responses ($F_{1,20} = 1.32$ $p > .05$) (see Figure 21).

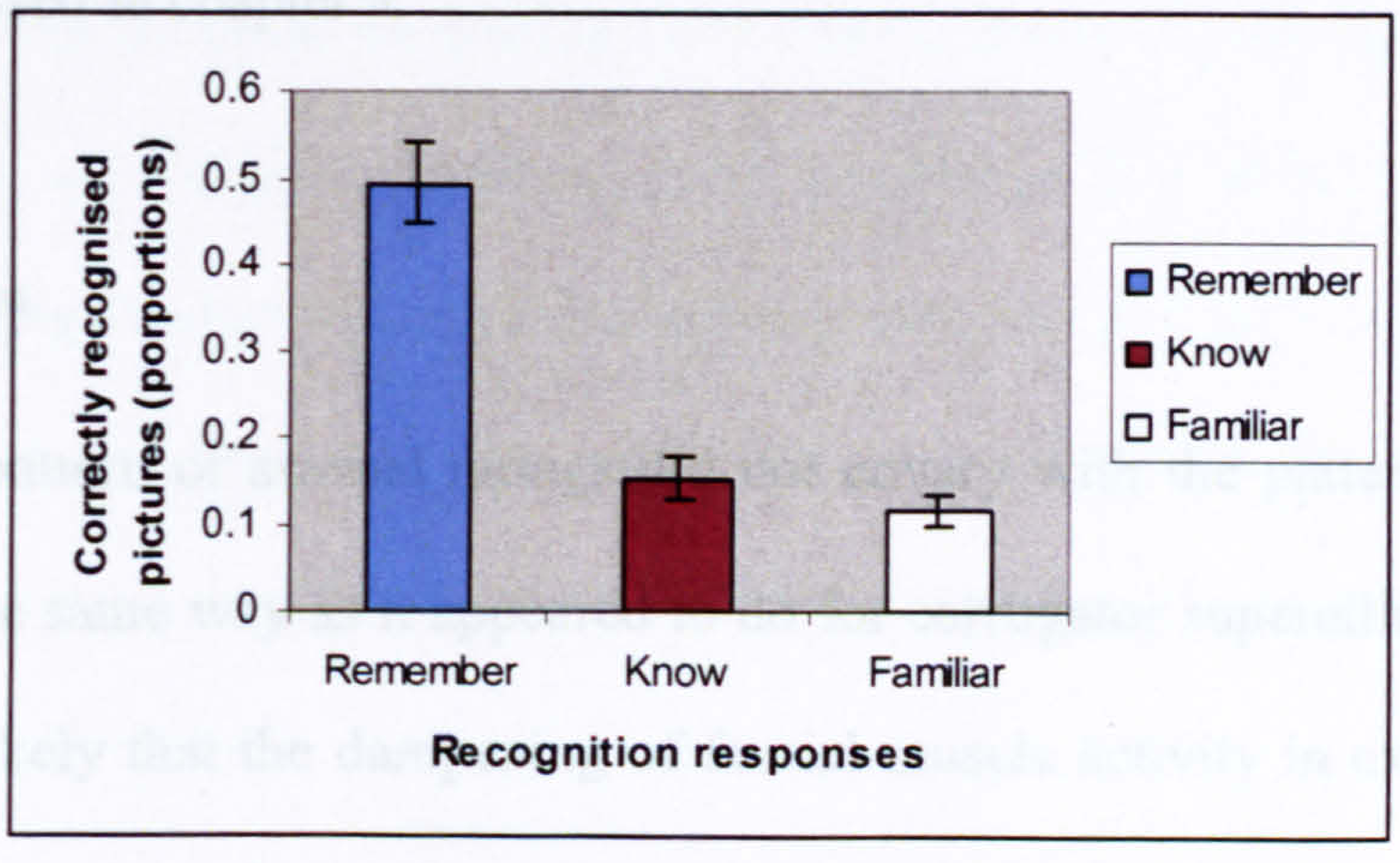


Figure 21: Proportions of remember, know and familiar responses for correctly recognised pictures

Recollection andFamiliarity

Analysis of recollection and familiarity showed lower levels of recollection for high arousal pictures and hence higher levels of recollection for low arousal pictures (see Table 18).

Table 18. Recollection and Familiarity as a function of arousal

	Recollection		Familiarity	
Arousal	No Load	Load	No Load	Load
High	.67	.67	.33	.33
Low	.72	.79	.28	.21

A statistical analysis of the familiarity measures using a 2x2 ANOVA with arousal and cognitive load as the independent variables showed no main effect of arousal (F<1) but a main effect of cognitive load ($F_{1,20} = 5.05$ $p < .05$ $d = .2$). Recollection was lower in the no load than the load condition (Means and SEs = .32 (.05); .22 (.04) showing that familiarity was higher in the no load condition. There was no significant Arousal x Cognitive load interaction ($F_{1,20} = 1.36$ $p > .05$). These results are discussed in chapter 8.

1.1.7. Discussion

Since the pattern of arousal ratings did not covary with the pattern of startle magnitudes in the same way as it appeared to do for corrugator supercilli activity, it would seem unlikely that the dampening of fascial muscle activity in experiment 2 resulted in a dampening of generated emotional responses. It could, however, have influenced the conscious experience of emotion. The fact that arousal ratings and startle magnitudes in this experiment did not show the same pattern of activity supports research evidence that suggests that the conscious experience of emotion and unconscious affect generation are products of separate systems. As Kappas (Kappas, 2006) and LeDoux (1996) maintain, therefore, self report may be a good measure of the experience of emotion but not the generation of emotion. However, the fact that distraction is a conscious process and did affect emotional responses in this experiment suggests that *indirect* conscious and intentional control may still regulate emotional responses with some success, by reducing cognitive resources available for processing attended stimuli.

Of particular importance in the results obtained was the significant reduction in eyeblink startle magnitudes in the cognitive load compared with the no cognitive load condition. In line with evidence from previous effortful distraction studies (Erk et al., 2006, Van Dillen and Koole, 2007), this was interpreted as a significant dampening of emotion when cognitive resources for processing the experimental pictures were reduced by the demands of the distractor task i.e. the instruction to 'hold in mind' the preceding face. This evidence is in line with that of Lieberman who maintains that cognitive processing generally draws attention away from, or is wired up to disrupt emotion processing (Lieberman, 2003). It also appears to be contrary to that of Ochsner, however, who maintains that effortful cognitive processing is engaged when up-regulating negative emotion and *increases* amygdala activity. However, in the latter case, cognitive processing *adds* resources to the attended task whereas in the above experiment cognitive resources were being *withdrawn* by the distractors.

The dramatic loss of a main effect of valence for startle magnitudes and the significant Valence x Cognitive load interaction that showed the loss of negative but not neutral affect in the load condition were interpreted, therefore, as significant evidence to support the claim that the use of a concurrent distraction task would tap into the same cognitive resources necessary to view the negative pictures and attenuate emotional responses. Furthermore, the effect was also apparent in explicit recognition memory where there was no Valence x Recognition interaction and hence no evidence of any normal negativity bias. Withdrawing cognitive resources appears to have resulted in the loss of stronger or more detailed memories for negative pictures.

Although the evidence supports an effect of reduced cognitive resources on affect modulation during on-going emotion generation and in recognition memory, it does not, as yet, resolve the problem of Vuilleumier's and Pessoa's conflicting evidence over the necessity of conscious attention for emotion generation (Pessoa et al., 2005a, Pessoa et al., 2002b, Pessoa et al., 2005b, Vuilleumier, 2005, Vuilleumier et al., 2001a, Vuilleumier et al., 2001b). Though the above evidence *may* support Pessoa's claims that conscious attention is required to generate affect (Pessoa et al., 2002a, Pessoa et al., 2002b, Pessoa et al., 2005b) it is still possible that *cognitive resources per se* and not specifically *conscious attention* is the mediating factor.

In order to specifically address the question of the need for conscious attention to generate emotion, it was decided to repeat the above experiment but tap into cognitive resources of a different modality (i.e. verbal resources rather than resources required for visual imagery) and observe the results. If visual attention is the primary factor, then an effect of cognitive load would be unlikely with verbal distractors as they would be unlikely to reduce visual resources. If startle magnitudes were smaller in the cognitive load than the no load condition, however, as in the above experiment, then the effect could be modality independent and perhaps due to underlying cognitive processes such as executive functioning (i.e. working memory). The next experiment, therefore, addressed the question of whether or not the cognitive resources involved are essentially attentional or more generally cognitive.

Chapter 6

Perception, Attention and Working Memory: Competition for Cognitive Resources

The terms *cognitive* and *cognition* date back to the 16th century and have been variously defined but generally refer to mental processes such as thinking, reasoning, perception, attention and memory. *Cognitive* is usually restricted to descriptions of the processes themselves so that the phrase *cognitive resources* generally refers to the limited mental means available to carry out cognitive processes such as perception, memory and attention, and more complex processes such as planning, problem solving and task switching.

Competition for cognitive resources was believed to have caused the fall in the magnitude of the acoustic startle in the cognitive load condition in experiment 3. In order to understand exactly what happened and why, it is necessary to know what cognitive resources are involved in processing visual stimuli, how they are organised and where in the procedure competition arises. Much research has investigated the perceptual, attentional and working memory processes involved in processing visual stimuli. The following chapter draws on research that appears particularly relevant to the knowledge required here.

1.1. Perception

According to Goodale and Milner (Goodale and Milner, 2006), the human visual system actually consists of two visual streams. The dorsal stream operates on-line in real time and registers spatial information that prepares and guides muscles for action e.g. arm, thumb and finger movements required to pick up a cup. The ventral stream, however, operates off-line and encodes visual information (e.g. physical features), necessary to identify objects. It is the ventral stream, therefore, that holds the information that can be used to construct meaning. The information held in the ventral stream, however, is very crude and requires further processing before interpretation is possible. Basically, individual physical features of the stimulus have to be recognised and then 'read' into working memory (Cowan, 1998) where they are combined into a visual image that represents the external stimulus.Visual working memory capacity is limited to a maximum of about 4 items for non-verbal stimuli when mnemonics and rehearsal are excluded (Luck and Vogel, 1997). Competition between items may thus involve competition for mechansims as well as resources.

1.1.2. Perception and Working Memory

When a visual stimulus has to be held in mind whilst a second visual stimulus is processed, there may well be competition for both mechanisms and resources. It is known, for example, that if the first stimulus is complex, processing may not be complete by the time the second stimulus is ready for registration. Normally, after the first stimulus has been processed, there is a period of approximately several hundred milliseconds, called the attentional blink, which clears the system for perceptual processing but during which the processing of subsequent stimuli is impaired (Awh *et al.*, 2006). Startle modification studies investigating the pre-pulse inhibition function of the amygdala, however, have shown that the amygdala can inhibit and delay the blink to allow complex processing of stimuli to be completed

(Bradley et al., 1993a). This competition for ventral stream access and delay in registration of the second stimulus results in the failure of the perceptual representation to gain access to working memory (Awh et al., 2006); an outcome that is consistent with research that indicates that the amygdala can bias the content of explicit memory (Cahill and Alkire, 2003). If the perceptual representations of both items enter working memory, then, although there is no competition for storage structures as stated above, there is competition for processing resources. Cognitive resources are required to maintain the first perceptual representation whilst interpretative and evaluative processing occurs in the PFC and also to maintain the second representation which may await the same processes. Evidence now suggests that whilst working memory may be required to recruit higher order cognitive processes in the PFC for stimulus interpretation and evaluation, attentional resources may be required to maintain the relevant perceptual representations in working memory that allow the prefrontal structures to proceed. Thus the perceptual respresentations of both stimuli need to be maintained and processed. Competition for attentional resources, therefore, may be part of the competition for cognitive resources generally.

1.1.3. Perception and Attention

Perception is largely automatic in the sense that what is seen is processed until capacity is exhausted (Lavie, 1995). Some voluntary control can be exerted, however, via the control of attention. Attention is described as, "a mental resource that is essential for information processing, exists in a limited amount, and can be allocated flexibly to various sources of information" (Gopher, 1992). Pre-attentive processing is the processing of objects prior to attentional selection (i.e. unattended objects), and post-attentive processing is the processing of objects within the focus of attention (i.e. attended objects) (Smilek *et al.*, 2007). Pre-attentive processing is fast, unconscious and automatic. Post-attentive processing is conscious and more detailed. Studies using event-related potentials (ERPs) have shown that ERPs for post-attentive stimuli are amplified within the visual cortex and that amplification can occur within the first 100ms of stimulus onset (Awh et al., 2006), indicating that attention has increased neural activation and hence perceptual processing efficiency. This has particular relevance for affective modulation of visual stimuli since a good quality visual percept has been shown to be necessary to activate the amygdala (Gläscher *et al.*, 2007). An important implication of this is that failure to activate the amygdala means a failure to attach affective valence to a stimulus. Hence a negative stimulus may acquire neutral valence, and if stored in memory, may be stored as a neutral memory.

Evidence of late post-attentive processing is also important since it can affect later stages of perceptual analysis i.e. during the construction of meaning (Fenske and Raymond, 2006). For example, Fenske and colleagues state that "attentional enhancement of perception may allow the meaning of a stimulus (e.g. an expressive face) to be more easily discerned" (Fenske and Raymond, 2006). In an ERP study, Codispoti et al maintain that their data suggests that an early ERP primarily reflects 'obligatory perceptual processing' and that a late ERP is due to 'increased resource allocation due to the motivational relevance of the affective cues' (Codispoti et al., 2007). Thus, attentional resources are vital for both early and late stages of perceptual processing.

When two or more stimuli both require processing, therefore, there is not only competition for perceptual resources but also attentional resources. Allport et al, (Allport *et al.*, 1972) demonstrated that two or more stimuli can be processed simultaneously if requiring different processing modalities (e.g. driving (visual) and talking (auditory & motor), and (Shiffrin and Schneider, 1977) demonstrated that both could also be processed simultaneously via divided attention if one was automatic (e.g. knitting and watching t.v.). However, when two stimuli both require full attentional resources, the problem has to be resolved via attention switching. The result, however, may be a degraded representation for the second object (Duncan, 1984, Luck and Vogel, 1997). Dividing attention temporarily, removes resources from the unattended object with inevitable perceptual costs. It also has important implications for both working and long term memories.

1.1.4. Perception, Attention and Working Memory

Working memory refers to processes that maintain an active representation of information over a brief period so that it is available for recall or further processing (Baddeley, 1986). Interactions between perception and attention are well researched as indicated in the previous section. Interactions between attention and working memory, however, are equally important. Research into spatial working memory and attention, in particular, demonstrates this. Studies have shown, for example, that when to-be-remembered objects are perceived, stored and recalled in the same locations, memory for these objects is enhanced, and impaired when locations differ (Awh and Jonides, 2001). Though research involving object identification appears less prolific, the effects of attention on memory may be equally important. For example, it has been demonstrated that objects in working memory can prime perception and capture attention for matching objects in the external environment (Awh et al., 2006). Cowan also maintains that subtle shifts in attention toward particular stimuli can "markedly improve memory for these stimuli" (Cowan, 1993). This interaction of perception, attention and working memory may indicate a functional role for attention-based rehearsal of objects in working memory. If this is so, it suggests that the same attentional resources may be involved in maintaining an image in working memory and in perceptually processing a new image, and this suggests yet more potential for resource competition.

Voluntary control of attention, however, introduces another factor. 'Executive' processes that guide voluntary action are believed to be localised in the LPFC and are usually thought to be the function of working memory (Ochsner et al., 2002). Selective attention, either directly via dispositional preferences or conscious regulation (Ochsner and Gross, 2005), for example, can increase activation to the attended stimulus via executive activation, and thereby bias perceptual processing. Thus, in addition to recruiting higher order processes of interpretation and evaluation by activating the MPFC, working memory may also control what is attended and for how long. In fact, it is recognised that the availability of working memory to actively maintain processing priorities is crucial for focusing attention (de Fokert *et al.*, 2001).

Working memory, however, would appear to have its own resources separate from attentional resources. Smith and Jonides describe 'executive processes' as "metaprocesses that regulate the processing of working-memory contents" (Smith and Jonides, 1998) and include controlling such functions as inhibition, attention switching and monitoring of information. When these resources are stretched by the processing demands of a task, resource competition could involve the competition for working memory resources as well as attentional resources.

1.1.5. Summary

The human cognitive system has limited capacity and resources. When two or more stimuli are processed simultaneously, competition for cognitive mechanisms and resources is almost inevitable. Due to capacity restrictions, competition for perceptual resources may primarily involve access to the ventral stream where complex visual stimuli may require time to process and thus shorten time available for processing incoming stimuli with impaired results. Attentional resources are known to increase neural activation of visual stimuli and hence also perceptual processing. When two or more stimuli require attention, attentional resources have to be divided with the unattended stimulus losing resources. Maintenance of attentional resources are required whilst higher order interpretations and evaluations of stimuli are in progress. Executive functioning resources (i.e. working memory resources) are required to control attention and are particularly relevant for successful attention switching in tasks requiring the maintenance and processing of more than one item. Executive functioning resources are believed to recruit higher order cognitive processes by activating relevant neural networks, and select stimuli for processing by increasing activation to attended stimuli, and thus biasing attentional resources, whilst higher order cognitive processes such as interpretation and evaluation occur. Competition for cognitive resources can occur in all cognitive systems therefore.

1.2. Distraction and the competition for Cognitive Resources

The relevance of limited cognitive resources for processing both experimental and distractor stimuli in studies of emotion is very clear. Since the distractor is presented first, and in the studies for this thesis, are viewed for 2000ms, there should be no decrement in perceptual processing since fully attended. In addition, the explicit instruction to hold the image in mind, will tend to bias attentional and working memory resources towards maintenance of the distractor item. However, reduced attentional and working memory resources may impair processing of the experimental image. Both perceptual processing (reduced attentional resources) and the construction of meaning (reduced attentional and/or working memory resources) may be impaired.

Traditionally, the generation of affective responses to visual stimuli was thought to be pre-attentive i.e. fast, unconscious and automatic. However, since recent research has found evidence for amygdala/PFC interactions and modulations of affective responses (Ochsner et al., 2002) cognitive theories of emotion generation that maintain the need for cognitive appraisal to generate affect have more validity. It is now considered more likely, therefore, that the generation of affective responses to external stimuli may require attention. There is a possibility, for example, that attention is required to generate a good quality percept capable of activating the amygdala (Gläscher et al., 2007), and that failure due to the competition for attentional resources could cause reduced startle magnitudes as in experiment 3. Alternatively, it is also possible that reduced attentional and/or working memory resources failed to facilitate the construction of meaning and hence affective responses and startle magnitudes.

Luiz Pessoa has recently re-opened the debate concerning conscious versus automatic attention and affective response generation by demonstrating that conscious attention *is* required and by claiming that previous evidence suggesting that it was an unconscious and automatic process could be flawed. (Pessoa et al., 2002b, Pessoa et al., 2005b). In the light of this evidence, it was decided that the next experiment in this study should test the hypothesis that the reduced startle magnitudes in the cognitive load condition in experiment 3, were due to reduced cognitive resources, as evidence from the distraction paradigm suggests, rather than more specifically, to reduced *attentional* resources.

1.3. Experiment 4: Reduced cognitive (executive function) resources or reduced attentional resources?

1.3.1. Introduction

Conflicting evidence over the need for pre-attentive (Killgore and Yurgelun-Todd, 2004, Öhman et al., 2001, Vuilleumier et al., 2001a, Vuilleumier et al., 2001b) and post-attentive processing (Pessoa et al., 2005a, Pessoa et al., 2002a, Pessoa et al., 2002b, Pessoa et al., 2005b) to activate the amygdala in response to fearful stimuli has been attributed to design flaws such as incomplete masking procedures or a failure to maximise the use of attentional resources in the pre-attentive studies (Pessoa et al., 2002a, Pessoa et al., 2002b, Pessoa et al., 2005b, Pessoa and Ungerleider, 2004). A possible reason for required post-attentive processing is suggested to be the need to inhibit and hence deactivate limbic regions during demanding cognitive tasks. Current research, however, suggests that the two systems are interactive (Ochsner et al., 2002, Ochsner and Gross, 2005), and a review of the literature suggests that post-attentive resources are required to construct and maintain good quality perceptual representations of external stimuli for affective processing. Using the acoustic startle as an indicator of amygdala activation, this study would manipulate conscious or post-attentive resources with verbal distractor items (e.g. words) and measure startle magnitudes when participants were viewing negative and neutral pictures. If smaller startle magnitudes again occurred in the cognitive load condition for negative pictures but not in the no load condition, it could be inferred that the reduction in resources could be modality independent and therefore likely to be due to increased executive functioning.

Supported by Joseph LeDoux's dual route model of emotion processing (LeDoux, 1996) traditional theories of emotion maintain that affective responses are triggered by the amygdala via an automatic and unconscious process that is independent of conscious cognitive processing. fMRI studies using backward masking of fearful stimuli such as angry faces, snakes and spiders (Öhman et al., 1995, Öhman and Mineka, 2001), neglect and visual extinction studies investigating activation of the visual cortex and ventral temporal cortex with and without conscious awareness (Vuilleumier et al., 2001b), and attention studies testing amygdala activation to fearful and neutral faces with and without conscious attention (Killgore and Yurgelun-Todd, 2004, Vuilleumier et al., 2001a), for example, have shown that conscious attention of a visual stimulus such as an angry face is *not* required in order to trigger the amygdala.

Evidence from studies by Luiz Pessoa, however, disputes this claim. In a backward masking study in which fearful faces were backward masked by neutral faces (Pessoa et al., 2005b), and in attention tasks in which participants were required to focus attention on faces with negative and neutral expressions in the centre of their visual field and make same/different orientation judgements about rectangular bars at various degrees of orientation in their peripheral visual field (Pessoa et al., 2002a, Pessoa et al., 2002b, Pessoa et al., 2005b, Pessoa and

Ungerleider, 2004), Pessoa et al demonstrated that conscious attention *is* required to trigger the amygdala.

To understand the differences between these results and those of previous experiments, Pessoa et al suggested that incomplete masking procedures (Pessoa et al., 2005a) and attention tasks that failed to utilize all available conscious attentional (post-attentive) resources could be responsible for evidence of unconscious and automatic activation of the amygdala (Pessoa et al., 2002b). They argued, that deactivation of emotion systems during cognitive processing would be "consistent with the idea that limbic regions would be inhibited during the performance of demanding cognitive tasks, which would constitute a form of emotional blunting during cognitive conditions" (Pessoa et al., 2005b). As they themselves acknowledge, however, this explanation assumes independent cognitive and emotion systems, and current research now suggests that the two interact.

Following evidence from effortful distraction studies that demonstrate reduced affective responses to anticipated negative events when participants engage in effortful distraction (Erk et al., 2006), and reduced negative mood following effortful distraction (Van Dillen and Koole, 2007), it was believed that reduced cognitive resources could be the reason for dampening of emotion. Having tested this in an *on-going* affect generation experiment (experiment 3) with similar results, it seems possible that reduced cognitive resources and hence reduced cognitive processing rather than direct inhibition of the limbic region, may explain the Pessoa et al results.

Using words as distractor items and hence verbal rather than visual processing, and the same basic design as before, the following experiment tested the hypothesis that reducing cognitive resources rather than specific attentional resources would reduce acoustic startle magnitudes. The rationale was that if the effect of startle reduction and hence affect modulation was shown to be modality independent, then increased executive functioning rather than a lack of conscious attentional resources would be a more likely cause.

1.3.2. Participants

Fifty participants, mainly postgraduates of mixed nationalities (25 male: 25 female: Mean Age = 24.98 SD = 5.93), from the University of Leeds, took part in the study as paid volunteers. As before, all participants completed the Centre for Epidemiological Studies Depression Scale (CES_D) (Radloff, L.S., 1977), prior to selection and, a short demographic questionnaire to fulfill ethical and experimental requirements and to ensure the selection of normal, healthy volunteers. Checks were also made for dyslexia and potential second language difficulties. Participants gave written informed consent before participating.

1.3.3. Stimuli and Design

As in experiment 3, one hundred and twenty eight pictures (64 negative: 64 neutral) were selected from the International Affective Picture System (IAPS)(Lang, Bradley & Cuthbert, 1999) to generate emotional responses and arousal levels. When possible, negative pictures were selected with low valence and high arousal ratings (Means: 2.52, 6.34): neutral pictures with average valence and low arousal ratings (5.17, 2.98). To form 2 blocks of pictures for the experimental conditions, equal numbers of each valence type were randomly assigned to each block, making 64 pictures per condition (32 negative: 32 neutral). Forty two of these (21 negative:

21 neutral) were randomly assigned to probed trials and 22 (11 negative: 11 neutral) to non-probed trials. Each picture was displayed on a computer screen for 5 seconds and was preceded by a white screen with a black fixation cross centered and displayed for 500ms.

On probed trials, the startle reflex was triggered by a 50ms 100Db burst of white noise generated at intervals of 2.5, 3.5 and 4.5 seconds from picture onset. A seven-point rating scale was displayed following each picture to prompt participants to register self-reported arousal ratings. A standard 7-key response pad with keys labeled 0 – 6 registered responses ranging from 0, "I feel absolutely nothing at all" to 6, "I feel extremely strong emotions". The rating scale was displayed until a response was registered or to a maximum time of 2 seconds. No more than four pictures of the same valence were displayed consecutively. Both pictures and conditions were fully counterbalanced.

The distractor task consisted of two conditions. In the no load condition words and non words formed a lexical decision task to be undertaken before and after viewing and rating experimental pictures and did not require working memory. In the load condition, words were used in a sample to test matching task with the sample word presented before the experimental picture and the test word immediately after, thus making working memory obligatory (see Figure 25). Fifty percent of trials in the load condition contained matching words and fifty percent non-matching words. All words used were selected from the MRC Psycholinguistic Database (2006) on the basis of similar word length, concreteness, imageability and familiarity ratings (see Appendix 5). To increase task difficulty and to reduce the risk of familiarity judgements in the cognitive load condition, 42% of words were repeated.

Each trial consisted of 5 screens including a word, a picture and a rating scale. In the cognitive load condition the first word of the following trial was used for the matching task making the design a traditional 1-back. Words were centred, preceded by a 1000ms fixation cross (not shown in Figure 22) and remained on the screen for 2 seconds. Pictures were presented as full screen images. The 64 trials in each condition (32 negative: 32 neutral) were divided into 3 blocks so that no block lasted longer than approximately 5 minutes. SuperlabPro software was used to create and run the computer programme and interfaced with a second computer that displayed a digital pulse alongside the orbicularis oculi waveform each time a picture was presented.

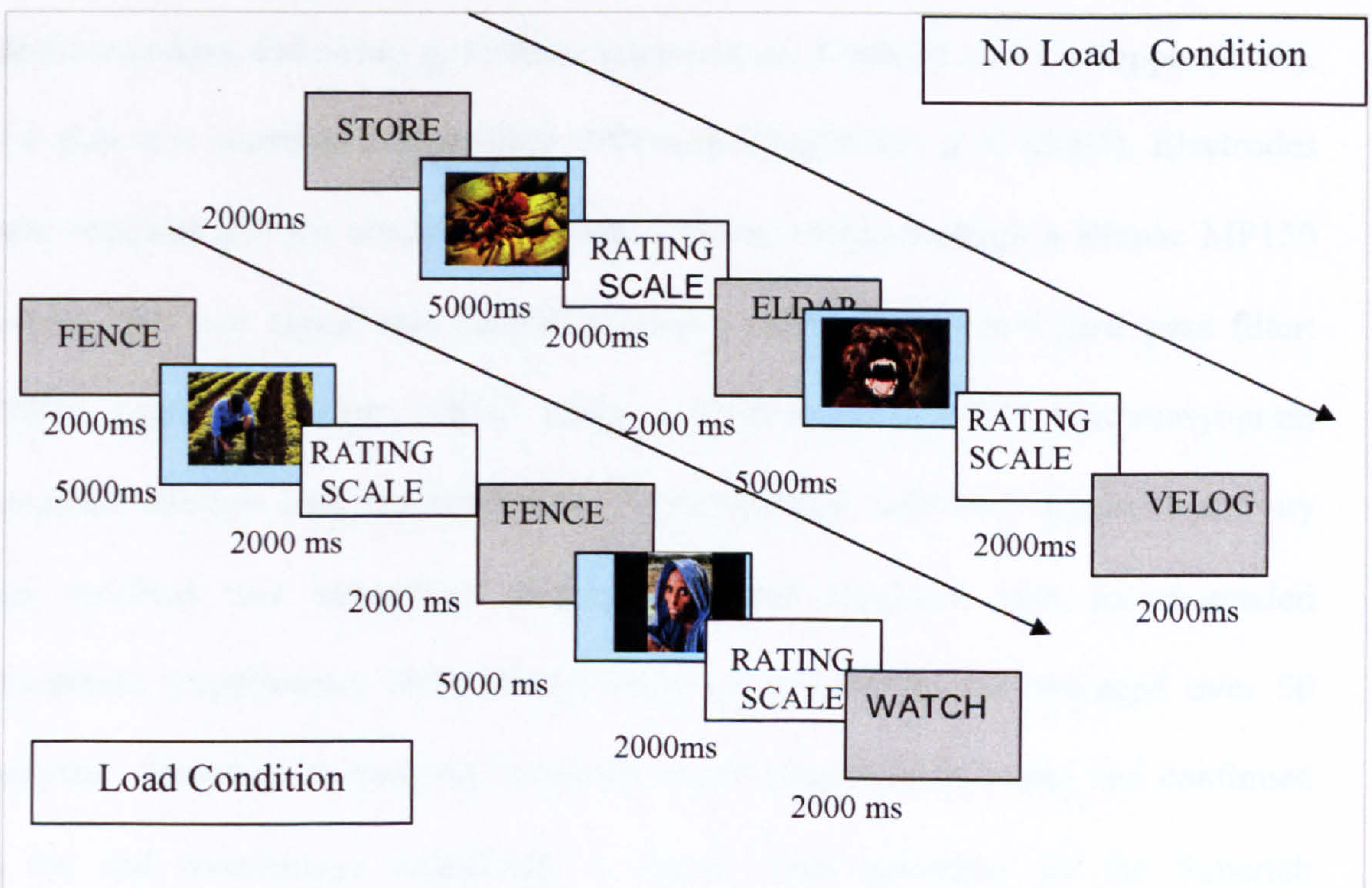


Figure 22: Presentation sequences for the No Cognitive Load and Cognitive Load conditions (see text for presentation details).

The recognition memory task consisted of one hundred and forty four pictures (96 old: 48 new; 72 negative: 72 neutral) presented as coloured thumbnails (height:

2.62cm; width: 3.18cm) on 5 pages of laminated card. The pictures were presented in 8 rows of 5 pictures per row per page, and a final page of the remaining 24 pictures. As in previous experiments, acetates were provided on which to record recognition responses: the letter R for remember, K for know and F for familiar. Percentages and of correctly recognised pictures together with missed images and false positives were recorded and analysed for recognition accuracy.

1.3.4. Physiological data collection and reduction

As before, raw electromyography (EMG) was recorded from the orbicularis oculi muscle beneath the left eye using 2 EL254S shielded electrodes and disposable adhesive collars following guidelines proposed by Fridlund and Cacioppo (2000). The skin was prepared and abraded following Blumenthal et al (2005). Electrodes were attached and the electromyographic activity routed through a Biopac MP150 system. The raw signal was amplified (Gain: 5000) and filtered (low pass filter: 500Hz; high pass filter: 10Hz) using a Biopac EMG 100C Electromyogram Amplifier Module and digitized using Acqknowledge Software. Eyeblink activity was rectified and integrated on-line following Biopac's own recommended procedures (Application Note H102), sampled at 1000Hz and averaged over 50 samples. Sampling started just before the experimental block began and continued to the end (continuous recording). A digital pulse generated by the Superlab software marked a point on the waveform immediately prior to each startle probe onset. The eyeblink reflex was then measured for 350ms from this point.

The magnitude of the startle eyeblink reflex was measured using the Biopac peak-to-peak (P-P) function. This function computes the difference in microvolts between the highest and lowest peak in the selected time window and pastes the outcome in the system's journal. The raw data was then converted to z scores and entered into an SPSS database for analysis using a 2x2 repeated measures ANOVA.

1.3.5. Procedure

Prior to the experiment, one hundred and forty six words were selected for the lexical tasks from the MRC Psycholinguistic Database (2006) on the basis of similar word length, concreteness, imageability and familiarity ratings. Twenty people rated the words on a 10-point analogue scale for degree of emotionality from 'Not at all emotional' to 'Extremely emotional' and labelled them for valence (i.e. positive, neutral or negative). Seventy one low arousal words labelled neutral were selected for the study. Five-letter non-words were constructed from the selected words (e.g. GLOVE .... VELOG, PEDAL ....ELDAP) for the no cognitive load condition.

Upon arrival at the laboratory, participants read background information to the study, received detailed instructions of the experimental requirements and then gave written informed consent. Participants sat facing a computer screen approximately 1 metre away with a response pad resting on the knee to minimize hand movements. After attaching the electrodes, a short equipment test was followed by a practice session of the first task to ensure familiarity with task instructions and timing. When viewing the pictures, participants were instructed to look at the screen for the full 5 seconds and only register their response when the rating scale appeared on the screen. They were also instructed to register their first spontaneous response and think only of its strength not the valence.

In the cognitive load condition, participants were required to hold in mind a preceding word ready for the post-stimulus sample to test matching task. This was in order to activate and maintain working memory activity in order to reduce available resources for processing the pictures. Responses to the lexical decision tasks were recorded using coloured keys on the response pad whilst the words were on the screen. The first experimental condition was then completed, followed by the second practice session and the second experimental condition. As before, the sequence of tasks undertaken was determined by counterbalancing requirements.

Participants were then required to complete the recognition memory task. Five laminated sheets of coloured thumbnail sized pictures were placed one at a time on a table in front of the participant. The task was to look at the pictures to see if any were recognised as having been in the previous computer presented experimental conditions. Recognised pictures were labelled R for remember (i.e. if the participant actively remembered a picture appearing on the computer screen, or remembered focusing on a particular part of a picture, or remembered something they had thought about at the time), K if they *knew* thay had seen the picture but had only a feeling of knowing with no mental 'evidence' to support it, and F if they had just a feeling of familiarity so it probably was in the study. Unrecognised pictures were left blank. After the recognition memory task, the electrodes were removed and participants were asked about their experience of the study and strategies used to remember pictures in the cognitive load (i.e. the sample to test matching) condition.

1.3.6. Results

1.3.6.1. Startle Magnitudes

In line with existing research, there was a main effect of valence ($F_{1,50}$=10.54 p<0.01 d=.17) with the magnitude of startle responses significantly larger for negative than neutral stimuli (Means and SE: negative: 0.20, .04; neutral: -.10, .03). However, there was no main effect of cognitive load ($F_{1,50}$= 1.0 p >0.05 d=.02) but, consistent with the hypothesis, a significant Valence x Cognitive load interaction ($F_{1,50}$= 11.43 p<0.01 d=.19). Significantly higher startle magnitudes were found for negative than neutral stimuli in the no load condition ($F_{1,50}$= 19.48 p=0.001 d=.28) and no significant differences in startle magnitudes in the load condition (F<1) (see Figure 23).

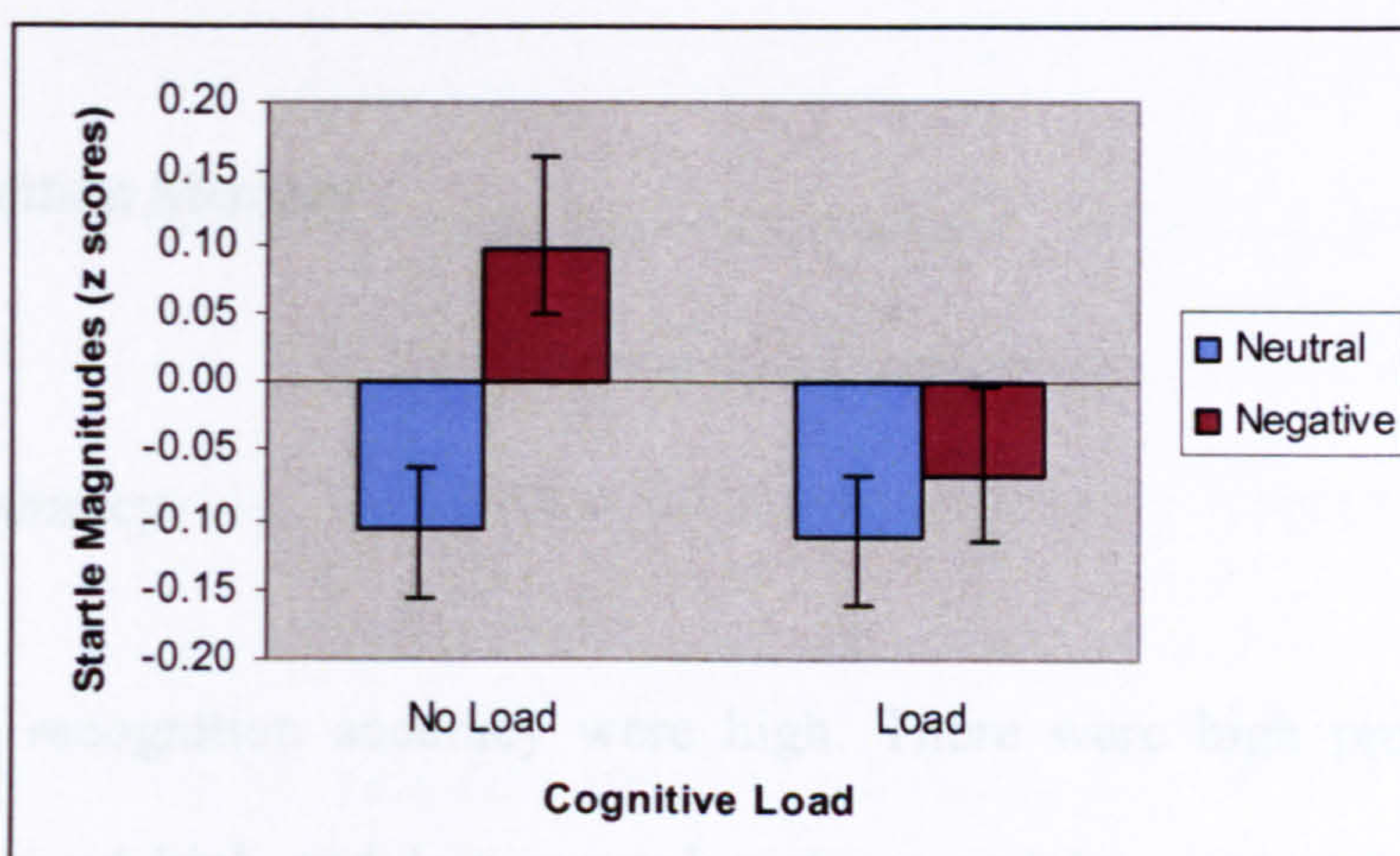


Figure 23: Startle responses to Negative and Neutral pictures in the No Load and Load conditions.

1.3.6.2. Arousal Ratings

As expected, there was a main effect of valence ($F_{1,50}$= 312.10 p<0.001 d=.86) with significantly higher arousal ratings for negative than neutral stimuli (Means and SE = (negative) 4.31, .12; (neutral) 2.39, .92) (see Figure 24). However, there was no main effect of cognitive load (F<1) and no Valence x Cognitive load interaction (F<1) (see Figure 24).

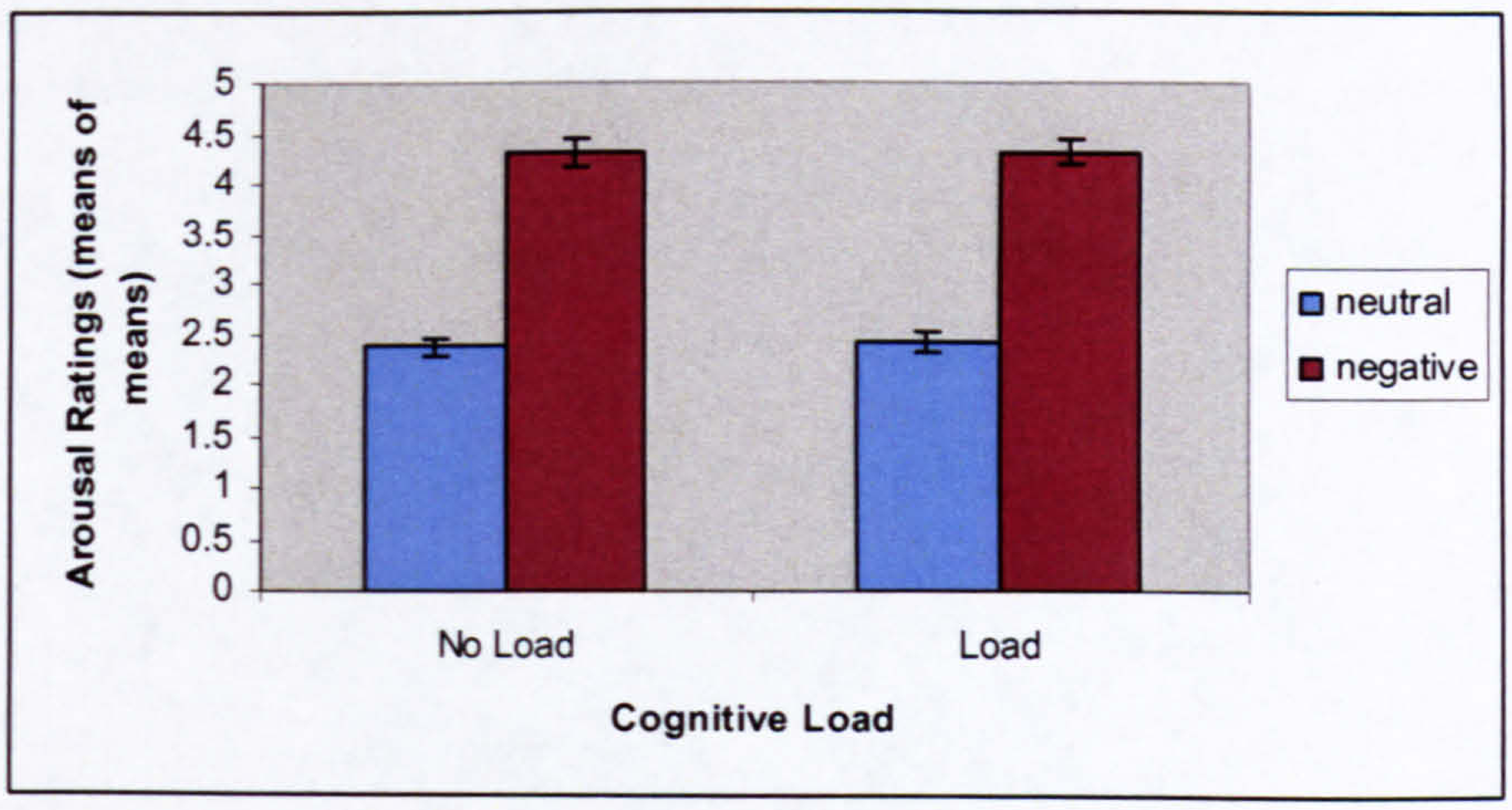


Figure24: Self Report Arousal Ratings for Negatively and Neutrally valenced pictures in the two conditions

1.3.6.3. Recognition Memory

Recognition Accuracy

Levels of recognition accuracy were high. There were high proportions of correctly recognised high and low arousal pictures and low proportions of false alarm data (see Table 19). Two outliers were adjusted following Tabachnick and Fidell (1997).

Table 19. Recognition accuracy as a function of arousal

Arousal	Hits	FAs	d'
Negative	.82	.03	2.67
Neutral	.62	.01	2.74

Statistical analysis of the recognition accuracy measures showed that d' was not significantly different for high and low arousal pictures ($t = .79$ $df = 49$ $p > .05$).

Remember, Know and Familiar responses

A comparison of simple proportions again showed more high arousal pictures correctly remembered compared with low arousal pictures (see Table 20).

Table 20. Proportions of R/K/F responses in the cognitive no load and load conditions

	No Load			Load		
Arousal	Remember	Know	Familiar	Remember	Know	Familiar
High	.60	.19	.10	.57	.16	.11
Low	.53	.20	.16	.46	.21	.10

Statistical analysis of simple proportions using a 2x2x3 ANOVA with arousal, cognitive load and recognition as independent variables showed a main effect of arousal ($F_{1,50} = 13.84$ $p < .01$ $d = .22$) and a main effect of cognitive load ($F_{1,50} = 4.04$ $p = .05$ $d = .08$). More high arousal pictures were correctly recognised than low arousal pictures (Means and SEs = .289 (.006); .267 (.007)) and the proportion was higher in the cognitive no load than the load condition (Means and SEs = .283 (.006); .273 (.006)). There was no Arousal x Cognitive load interaction ($F<1$). There was, however, a main effect of recognition ($F_{2,100} = 108.19$ $p <.001$ $d =.68$) with significantly more Remember than Know responses ($F_{1,50} = 95.10$ $p <.001$ $d =.66$) (Means and SEs = .58 (.03); .15 (.02)) and more Remember than Familiar responses ($F_{1,50} = 175.41$ $p < .001$ $d = .78$) (Means and SEs = .58 (.03); .11 (.01)). There was no significant difference between Know and Familiar responses ($F_{1,50} = 2.0$ $p >.05$). There was an Arousal x Recognition interaction ($F_{2,100} = 3.74$ $p < .05$ d

= .07) with significantly more high than low arousal pictures remembered ($F_{1,50}$ = 8.33 p <.01 d = .14). There were no significant differences in the proportions of Know responses ($F_{1,50}$ = 1.04 p >.05) and Familiar responses to high and low arousal pictures ($F_{1,50}$ = 1.76 p >.05) (see Figure 25). There was also no three-way Arousal x Cognitive load x Recognition interaction ($F_{1.5,73.7)}$ = 1.16 p >.05).

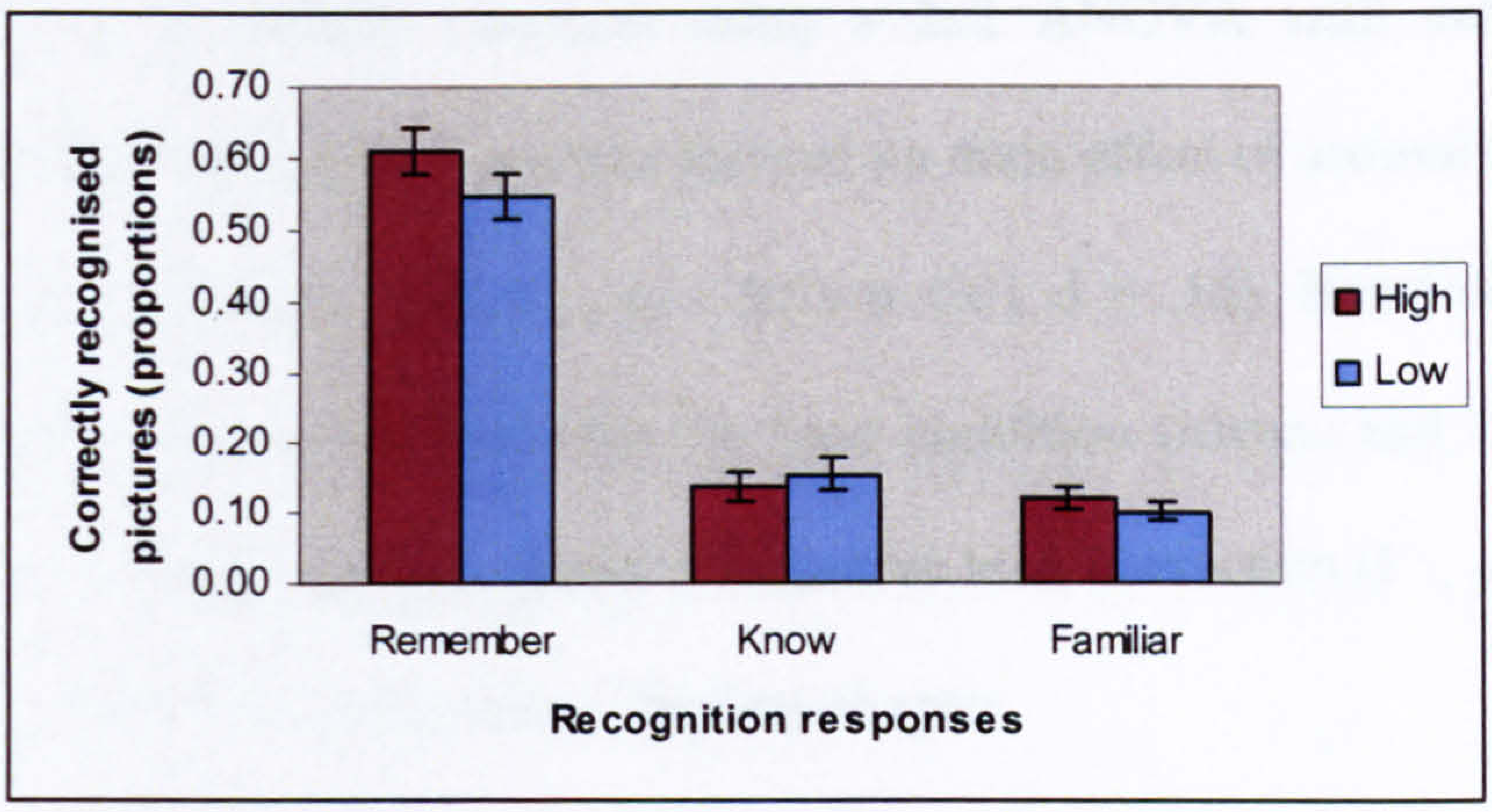


Figure 25. Proportions of remember, know and familiar responses to high and low arousal pictures

Recollection and Familiarity

Familiarity measures showed a mixed pattern with less familiarity for low arousal than high arousal pictures in the cognitive no load condition but more familiarity in the load condition. (see Table 21). Recollection, therefore, was higher for low arousal than high arousal pictures in the no load condition making familiarity greater for high arousal than low arousal pictures in the load condition.

Table 21. Recollection and Familiarity as a function of arousal

	Recollection		Familiarity	
Arousal	No Load	Load	No Load	Load
High	.52	.63	.48	.37
Low	.57	.61	.43	.39

Analysis of familiarity measures using a 2x2 ANOVA with arousal and cognitive load the independent variables showed no main effect of arousal ($F<1$) but a main effect of cognitive load ($F_{1, 50} = 9.53$ $p <.01$ $d = .16$). Recollection was significantly lower in the no load than the load condition (Means and SEs = .37 (.04); .28 (.04)). There was no Valence x Cognitive load interaction ($F_{1, 50} = 2.35$ $p >.05$). The results will be discussed in the final chapter.

1.3.7. Discussion

As predicted, startle magnitudes in the cognitive load condition were smaller than in the no load condition suggesting that the distractor task had again reduced cognitive resources and impaired affect modulation. Since the effect of the distractor task using a verbal processing modality reduced startle magnitudes in the cognitive load condition in the same way as a task using a visual processing modality (experiment 3), at least some of the effect could have been modality independent and better explained via a reduction in *cognitive resources per se* rather than a reduction in conscious attention. However, it is also possible that though verbal distractor items are processed automatically and may be phonologically rehearsed to maintain in working memory, it is possible that they were also processed visually. There was some evidence to support the hypothesis that the cognitive resources reduced could have been withdrawn from underlying processes such as executive functioning (i.e. working memory), but it is also acknowledged that visual attentional resources may also have been reduced.

To summarise, it is believed that increasing executive functioning reduces resources available for processing attended stimuli and may either involve, or result in, a reduction in visual attentional resources. What is certain is that increasing executive functions that use the same processing modality as visual attentional resources produces the greatest reduction in emotional processing of visual stimuli.

The modulation of affective responses indicated by the reduced startle magnitudes in the cognitive load condition, however, was expected to show a significant dampening of emotion in recognition memory as had been seen in experiment 3. The fact that it didn't was disappointing. As noted in chapter 1, research shows that the amygdala can modulate the consolidation of explicit memories by releasing stress hormones such as adrenalin (Cahill and Alkire, 2003, Phelps, 2004) so that in this study it could be expected that there would be a significant valence by cognitive load interaction with a reduced number of correctly recognised negative pictures in the cognitive load condition. One possible explanation for no such effect could have been the small effect size that may have been due to the use of words as distractor items. Awh and Jonides (2006) state that semantic processing of words is automatic and unconscious. Semantic processing could, therefore, have aided memory leaving working memory resources only slightly depleted for stimulus processing and therefore not impairing memory. Instead, there would have been slightly less affective intensity in recognition memory but enough to leave the negativity bias intact.

Though the need for cognitive resources to generate affect appears clear, what is still unclear is whether resources are required for early or late stages of cognitive processing. Phan (2002) maintains that amygdala activation is associated primarily with the sensory/perceptual level and is therefore more likely to be required for obligatory perceptual processing. Awh et al (2006) maintain that post-attentive ERPs can occur within the first 100ms of stimulus onset which suggests that conscious attention may be required for early perceptual processing. However, there is no apparent competition for resources at this level. Only two items require processing so neither competes for ventral stream or working memory space. What they do compete for is working memory resources to construct meaning. Codispoti et al (2007) maintain that meaning may be processed between 300-600ms post-stimulus onset when self relevance evaluations occur. (Gard *et al.*, 2007) also showed that scenes directly threatening to the viewer showed an enhanced startle response at 300ms; a result that suggests self relevance evaluations occurred before 300ms post-stimulus onset. Ochsner (2004) also maintains that conscious attention could be needed within the 300-600ms interval to enable interpretations of meaning and evaluations of self relevance. Since startle magnitudes in experiments 3 and 4 were measured at 2.5, 3.5 and 4.5 seconds post-stimulus onset, it is possible that cognitive resources were required for the construction of meaning. Evidence doesn't yet exist for the *generation* of affect via meaning, only for up or down-regulated affect that has already been generated (Ochsner et al., 2004).

However, consideration of an effect of meaning raises a further explanatory possibility for the results above, namely that that cognitive *outcomes* rather than cognitive *processes* could produce the effect. This explanation suggests that responses to negative pictures could have been attenuated by a 'dilution' of negative affect due to the simultaneous holding in mind of neutral distractor items i.e. that holding in mind a neutral word or pleasant face whilst viewing negative pictures would have generated neutral or even positive affect that could have down-regulated normal affective responses to the negative pictures. If the processing of meaning was not delayed or impaired by reduced cognitive resources, then an effect of congruence (or incongruence) could explain the results. In order to rule out a possible effect of simultaneous but incongruent responses, a fifth experiment was designed to test for this effect.

1.3.8. Summary

The results from experiment 3 suggested that the processing of experimental stimuli was impaired due to reduced cognitive resources required by an obligatory concurrent distraction task, and that the reductions caused startle magnitudes during picture presentations to fall and emotional responses in recognition memory to be attenuated. This was interpreted as indicating a loss of affect modulation due to reduced amygdala activity. However, it was unclear as to exactly what cognitive resources were involved or how. The results from experiment 3 suggested that cognitive resources could have been lost from visual attention. However, experiment 4 repeated the experimental design using a different processing modality (i.e. with *words* as distractor items and hence verbal rather than visual processing) and found that cognitive resources were still reduced and emotion attenuated during emotion generation though not in recognition memory. This was interpreted as possible evidence for affect modulation effects due to the loss of cognitive resources per se rather than a specific loss of conscious, visual attention as seemed likely in experiment 3. However, since executive functioning resources are known to control attentional resources and attention switching behaviour (Christoff, 1999), it is conceivable that a possible loss of cognitive resources resulted in the loss of conscious attention. In either event, the evidence appears to support Pessoa's claim that emotion generation is not entirely automatic and unconscious.

Although it is believed that the above experiments demonstrate that cognitive resources are required for emotion generation, it is still unclear as to whether the cognitive resources lost in the above experiments were required for early, low level cognitive appraisals or later, higher level meaning construction. It is also possible that cognitive *outcomes* rather than *processes* were responsible for the results and that stimuli producing conflicting affective responses could have confounded responses. In order to disentangle the potential effects of meaning construction (processes) versus constructed meanings (outcomes) on affective responses, a fifth experiment was designed to address the problem.

Chapter 7

Congruence versus Cognitive resources

The results from experiments 3 and 4 indicated that reduced cognitive resources, perhaps required for working memory functions, modulated affect during the generation of emotion and at times modulated emotional responses in recognition memory. However, there was also the possibility that cognitive *outcomes* rather than *processes* could have produced the same results. If cognitive resources were not reduced, meanings could have been constructed and incongruent distractor items (i.e. neutral or pleasant distractor items paired with negative pictures), for example, could have modulated affective responses to negative pictures by 'diluting' negative responses. If resources were reduced, then the construction of meaning may have been impaired resulting in a failure to generate a fully intensive affective response.

Human cognitive resources are known to be limited as previously discussed. Both perceptual and attentional capacities have been extensively researched and have been shown to be incapable of processing all in-coming information in the external environment. The limitations of working memory have also been highlighted in research investigating such proposed modules as the visual spatial scratchpad, the acoustic store, and the phonological loop (Baddeley, 1992). Less well researched, however, is the network that constructs meaning. Ochsner and colleagues have shown that meaning construction is carried out in various parts of the PFC (Ochsner et al., 2002, Ochsner et al., 2004), but exactly how these networks are activated and whether or not they have capacity restrictions is still largely unknown. One computer model that offers a description of potential processes, however, is the Intelligent Distribution Agent (IDA) (Baars and Franklin, 2003).

Substantiated by the IDA model that has successfully demonstrated human abilities like temporal deliberation, voluntary action selection and negotiating in natural language (Baars and Franklin, 2003), Baars suggests that the human brain is constantly cycling information through parallel and unconscious networks that compete for conscious attention. Consciousness, he maintains, is necessary to recruit networks and processes that construct meaning. Consciousness can broadcast information to widely distributed unconscious specialized networks in the human brain and in so doing recruit long term memory and networks such as problem solving and evaluation networks to help construct meaning. However, consciousness has limited capacity and enforces serial rather than parallel processing. Global constraint satisfaction, Baars suggests, is the method by which one and only one set of information becomes conscious. Basically, information that is most strongly activated wins the competition and settles into a stable network that becomes conscious. Consciousness, therefore is the outcome of global constraint satisfaction and is necessary to construct meaning.

However, by consciousness, Baars appears to be referring to what Frijda terms second order consciousness. In his article on emotion experience (2005 p476), Frijda makes the distinction between 'first order perceptual experience' and 'second order awareness'. The first is awareness without focal attention as when engaged in two concurrent tasks of which one is automatic and therefore requires little attention (e.g. driving and holding a conversation). The second involves full conscious awareness of events and a meaningful perception of the world (e.g. when attempting to avoid an accident on the road ahead). Not all cognitive psychologists believe that affect generation requires full conscious attention and the construction of sophisticated meaning, however. For example, Magda Arnold suggested that cognitive appraisals were likely to be 'direct and intuitive' and may not be 'the result of reflection' (Arnold, 1960) suggesting, perhaps, that they need only first order perceptual experience. The level of meaning required for the generation of affect, therefore, is still controversial and a failure of a congruency effect may not demonstrate a failure of reduced cognitive resources to construct meaning from higher order interpretative and evaluative processes.

Nevertheless, the aim of the fifth experiment was to manipulate meaning by manipulating congruence and see if cognitive resources and processing, or cognitive outcomes and congruence could best explain the modulated affect in experiments 3 and 4. If congruence was the major factor, then startle magnitudes generated by negative experimental pictures paired with neutral distractor pictures would be higher in the no load than the load condition. Negative pictures paired with negative distractor pictures would be likely to be higher in the load condition. If reduced cognitive resources was the major factor, then startle magnitudes for negative pictures would be higher in the no load condition regardless of congruence.

1.1. Experiment 5

1.1.1 Introduction

In a series of experiments, Ochsner has demonstrated the ability of meaning to modulate affective responses to external stimuli (Ochsner et al., 2002, Ochsner and Gross, 2005, Ochsner et al., 2004). Quoting Shakespeare's Hamlet, "there is nothing either good or bad, but thinking makes it so" (Shakespeare, 1998/1623), Ochsner (2002) makes the point that the way reality is interpreted determines the way we feel about it. Building on work done primarily by James Gross (Gross, 1998b, Gross, 2002, Gross and Levenson, 1993, Gross and Levenson, 1997b), Ochsner used fMRI technology to identify the regions controlling cognitive re-appraisal. In experiments in which he manipulated behaviour with "Attend" and "Re-appraise" instructions, he discovered that two major areas of the PFC are involved in re-appraisal, namely the LPFC and the MPFC, and that activation of the ventral LPFC was inversely correlated with activation of the amygdala and MOFC (Ochsner et al., 2002). From these results, he maintained that whilst the amygdala is important for detecting and recognising affectively salient stimuli and modulating implicit memory, it is the MOFC that is important for representing the pleasant or unpleasant afffective value of a stimulus "in a flexible format that is sensitive to momentary changes in social or motivational context" (Ochsner et al., 2002).

In later experiments, Ochsner also manipulated meaning construction with a self-focused and situation focused instruction. In these experiments, participants either took a subjective, self-focused perspective, and increased or decreased emotional responses by worsening the interpretation of an event or improving the likely consequences for themselves, or took an objective, situation focused perspective, and manipulated emotional responses in the same way but for a stranger. The results showed that amygdala activation either increased or decreased according to the improve or worsen conditions. Regions in the PFC shown to modulate amygdala activity were identified as the left rostromedial PFC, the right lateral and orbital PFC in down-regulation, medial prefrontal regions in the self-focused condition and lateral prefrontal regions in the situation focused condition. The left rostromedial PFC was believed to increase the emotional experience by drawing upon additional emotion knowledge, the right lateral and orbital PFC was believed to decrease the emotional response via behavioural inhibition. Thus, once again, the PFC was seen as a major region involved in modulating the amygdala with specific regions functioning to produce required outcomes for different regulatory goals and with different perspectives.

Since the acoustic startle reflex had been used in experiments 3 and 4, reported earlier, to indicate amygdala activity, it is possible that the reduced startle magnitudes in the cognitive load condition (i.e. the condition in which distractor items had to be held in mind for a sample to test matching exercise), might have been reduced by a failure of cognitive resources to allow meaning construction. If meaning is an important process in the generation of affect, then a failure to provide enough resources to either complete detailed feature analysis for accurate interpretation of the stimulus, or a failure to produce enough activation to broadcast the contents of working memory in order to recruit higher order interpretative and evaluative processes (Baars and Franklin, 2003) could have impaired processing in the prefrontal regions identified by Ochsner as important in the construction of meaning.

Although results from all experiments run so far have indicated a separation of conscious experience and unconscious processing, it is possible that meaning construction may have been impaired for affect generation but not for conscious experience. It is possible, for example, that resources were reduced for unconscious processing but not conscious processing and that, as a result, the two systems have become 'de-synchronised'.

The following experiment, therefore, was designed to test the hypothesis that conflicting affect generated by incongruent distractor and experimental pictures modulates unconscious affective responses. It was decided to use the same basic design as in experiments 3 and 4, but present negative and neutral pictures as distractor items as well as experimental stimuli, and manipulate congruency (i.e. negative distractor followed by a negative experimental stimulus (congruent condition); neutral distractor followed by a negative experimental stimulus (incongruent condition), and vice versa for neutral pictures). It was predicted that if congruency (or meaning) modulates affective responses, then there would be a significant main effect of congruence. Startle magnitudes for congruent negative stimuli would be significantly larger than startle magnitudes for incongruent negative stimuli. However, if reduced cognitive resources modulates affective responses, then there would be a valence x cognitive load interaction as seen in experiments 3 and 4, with attenuated affective responses to negative stimuli in the cognitive load condition.

1.1.2. Participants

Thirty six participants (30 female: 6 male), all undergraduates and post-graduates at the University of Leeds (Mean age: 20.61 SD 3.01) took part in the study for course credits or £10.00. All completed the Centre for Epidemiological Studies Depression Scale (ces_d) (Radloff, 1997), a short questionnaire designed to identify depression in the general population, and a short demographic questionnaire designed to exclude volunteers with phobias, pacemakers, traumatic memories, and cultural backgrounds or dispositions that would make viewing the negative pictures used in the study unacceptable. Participants with ces_d scores above 16 (i.e. scores that indicated possible depression) were excluded. All participants gave written informed consent to participate and were randomly assigned to one of three groups for version manipulations.

1.1.3. Stimuli and Design

Three hundred and fifty two pictures (176 negative: 176 neutral) were selected from the IAPS picture set, medical libraries and Google images to generate emotional responses and arousal levels. Mean arousal ratings were 5.96 for negative pictures and 2.74 for neutral pictures. To form 2 sets of pictures for the cognitive load and no load conditions, 192 pictures (96 negative: 96 neutral) were quasi-randomly assigned to the no load condition (some picture selection was controlled to match mean arousal ratings in the two conditions) and the remaining 160 pictures (80 negative: 80 neutral) were assigned to the load condition.

Each condition consisted of 64 trials (32 negative: 32 neutral) of which 42 were probed and 22 non-probed. On probed trials, the startle reflex was triggered by a 50ms 100dB burst of white noise generated quasi-randomly at 2.5, 3.5 and 4.5 seconds after picture onset. All trials constructed consisted of 10 screens consisting of prompt screens, pictures and a rating scale as shown in Figure 26 and fixation crosses (not shown). Fifty percent of the trials were congruent and 50% incongruent. Trials were congruent when the valence of the preceding picture in the distractor task matched the valence of the experimental picture (i.e. both were negative or neutral), and incongruent when they did not match (i.e. one neutral and one negative).

Cognitive load was manipulated in the load condition with a distracting visual matching task requiring working memory to maintain whilst viewing and rating the experimental picture. Of the 64 experimental trials, thirty two (16 negative: 16 neutral) consisted of matching test to sample pictures and thirty two (16 negative: 16 neutral) consisted of non-matching test to sample pictures. The no load task required an indoors/outdoors decision, registered at the time of picture presentation, regarding the most typical location of the distractor picture content. A blank screen and fixation cross, each displayed for 500ms, preceded each screen. Two versions of the study were constructed to fully counterbalance the pictures. In each version, all pictures appeared only once (apart from the 50% of matched pictures in the load condition), and in one condition only.

In order to control for boredom and to give participants rest periods in which they could move, trials in both conditions were divided into 3 blocks and no block lasted for more than approximately 5 minutes.

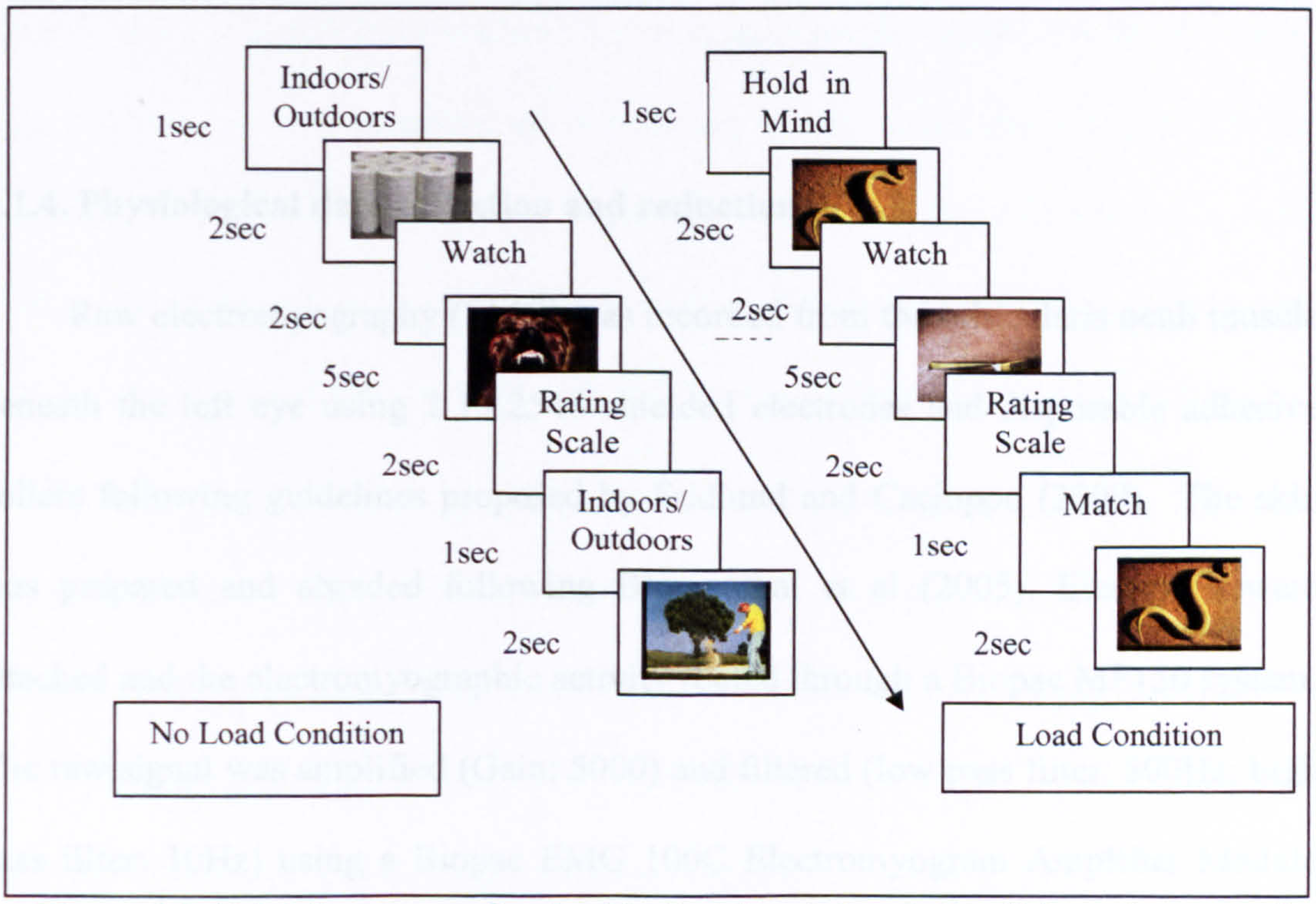


Figure 26: Trial Structures for the No Load and Load Conditions (see text for image specifications)

The recognition memory test consisted of one hundred and ninety six pictures (96 old: 96 new; 48 negative: 48 neutral from each set) presented as coloured thumbnails (height: 2.62cm; width: 3.18cm) on 4 pages of laminated card. The pictures were presented in 8 rows of 5 pictures per row per page, and a final page of the remaining 36 pictures. Foils and experimental pictures were matched by category (see Appendix 2) and arousal levels. Arousal levels were once again significantly higher for negative experimental pictures than foils ($t = 9.13$ $df = 94$ $p < .05$), however, as they were for neutral pictures ($t = 9.89$ $df = 94$ $p < .05$). As in previous experiments, acetates were provided on which to record recognition responses: the letter R for remember, K for know and F for familiar. Mean arousal ratings for negative and neutral pictures were 5.84 and 2.48 respectively. Percentages of correctly recognised pictures together with missed images and false positives were recorded.

1.1.4. Physiological data collection and reduction

Raw electromyography (EMG) was recorded from the orbicularis oculi muscle beneath the left eye using 2 EL254S shielded electrodes and disposable adhesive collars following guidelines proposed by Fridlund and Cacioppo (2000). The skin was prepared and abraded following Blumenthal et al (2005). Electrodes were attached and the electromyographic activity routed through a Biopac MP150 system. The raw signal was amplified (Gain: 5000) and filtered (low pass filter: 500Hz; high pass filter: 10Hz) using a Biopac EMG 100C Electromyogram Amplifier Module and digitized using Acqknowledge Software. Eyeblink activity was rectified and integrated on-line following Biopac's own recommended procedures (Application Note H102, sampled at 1000Hz and averaged over 50 samples. Sampling started just before the experimental block began and continued to the end (continuous recording). A digital pulse generated by the Superlab software marked a point on the waveform immediately prior to each startle probe onset. The eyeblink reflex was then measured for 350ms from this point.

The magnitude of the startle eyeblink reflex was measured using the Biopac peak-to-peak (P-P) function. This function computes the difference in microvolts between the highest and lowest peak in the selected time window and pastes the outcome in the system's journal. The raw data was then converted to z scores and entered into an SPSS database for analysis using a 2x2 repeated measures ANOVA.

1.1.5. Procedure

Prior to the experiment, three hundred and ninety six negative and neutral pictures were selected from medical libraries and Google images for the distractor task. All images were then divided into blocks of approximately 100 pictures and surveyed by 20 University of Leeds students and rated for valence and arousal levels. Two hundred and twenty images were then selected from the total surveyed (see Appendix 6) and together with 132 IAPS pictures formed a picture database.

Before the experiment, participants received information regarding the study and completed the ces_d (Radloff, 1977) and the demographic questionaires. On arriving at the laboratory, they read an information sheet reminding them of the nature and purpose of the study and then received a detailed description of the proposed procedure in order to give informed consent. Once consent had been given, electrodes were attached, the equipment tested, waveforms inspected and the first practice session begun. Participants practised each task immediately before the recorded experimental condition was undertaken and were allowed to practise until familiar with the instructions and timing of the study. The first experimental condition then followed . The second practice session enabled participants to become familiar with the second task and was then followed by the second experimental condition. The order of experimental conditions was determined by counterbalancing requirements. A set of 'Feel Good' pictures (i.e. positive pictures designed to create a positive mind set) concluded the computer session.

Participants were then required to complete the recognition memory task. Five laminated sheets of coloured thumbnail sized pictures were placed one at a time on a table in front of the participant. The task was to look at the pictures to see if any were recognised as having been in the previous computer presented experimental conditions. Recognised pictures were labelled R for remember (i.e. if the participant actively remembered a picture appearing on the computer screen, or remembered focusing on a particular part of a picture, or remembered something they had thought about at the time), K if they *knew* thay had seen the picture but had only a feeling of knowing with no mental 'evidence' to support it, and F if they had just a feeling of familiarity so it probably was in the study. Unrecognised pictures were left blank. After the recognition memory task, the electrodes were removed and participants were asked about their experience of the study and strategies used to remember pictures in the in the cognitive load (i.e. the sample to test matching) condition.

1.1.6. Results

1.1.6.1. The Eyeblink Startle Reflex (orbicularis oculi)

Consistent with previous results, there was a main effect of valence ($F_{1,35}$ = 19.38 p < 0.001 d = .36) but no main effect of cognitive load (F<1). There was also no main effect of congruence (F<1) and no interaction of Valence x Congruence (F<1), Congruence x Cognitive Load (F<1), or Valence x Congruence x Cognitive load (F<1). However, as before, there was a significant interaction between valence and cognitive load ($F_{1,35}$ = 4.45 p < 0.05 d = .11). Startle magnitudes were higher for negative than neutral pictures in both the no load and the load conditions (see Figure 27). However, the effect size in the no load condition (F = 16.88 p<.001 d =.33) was nearly twice the size of that in the load condition (F = 7.40 p < .02 d = .18).

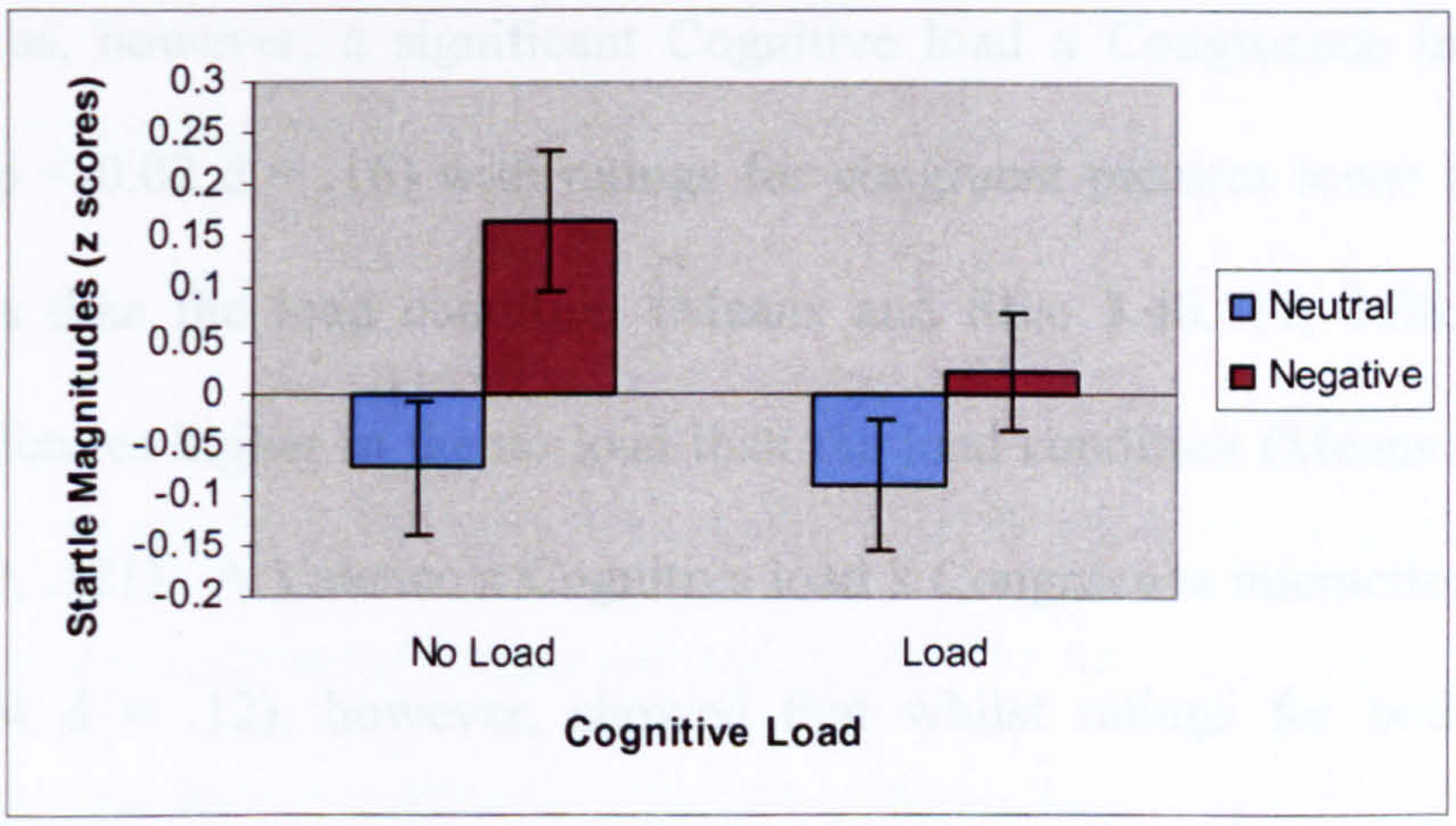


Figure 27: Startle responses to Negative and Neutral pictures in the No Load and Load conditions.

1.1.6.2. Arousal Ratings

There was a main effect of valence ($F_{1,35} = 203.54$ $p < 0.001 = .85$) with higher arousal ratings for negative than neutral pictures (Means and SEs = 4.57, .12; 2.46 .14) and no main effect of cognitive load ($F<1$) or congruence ($F<1$) (see Figures 28 and 29).

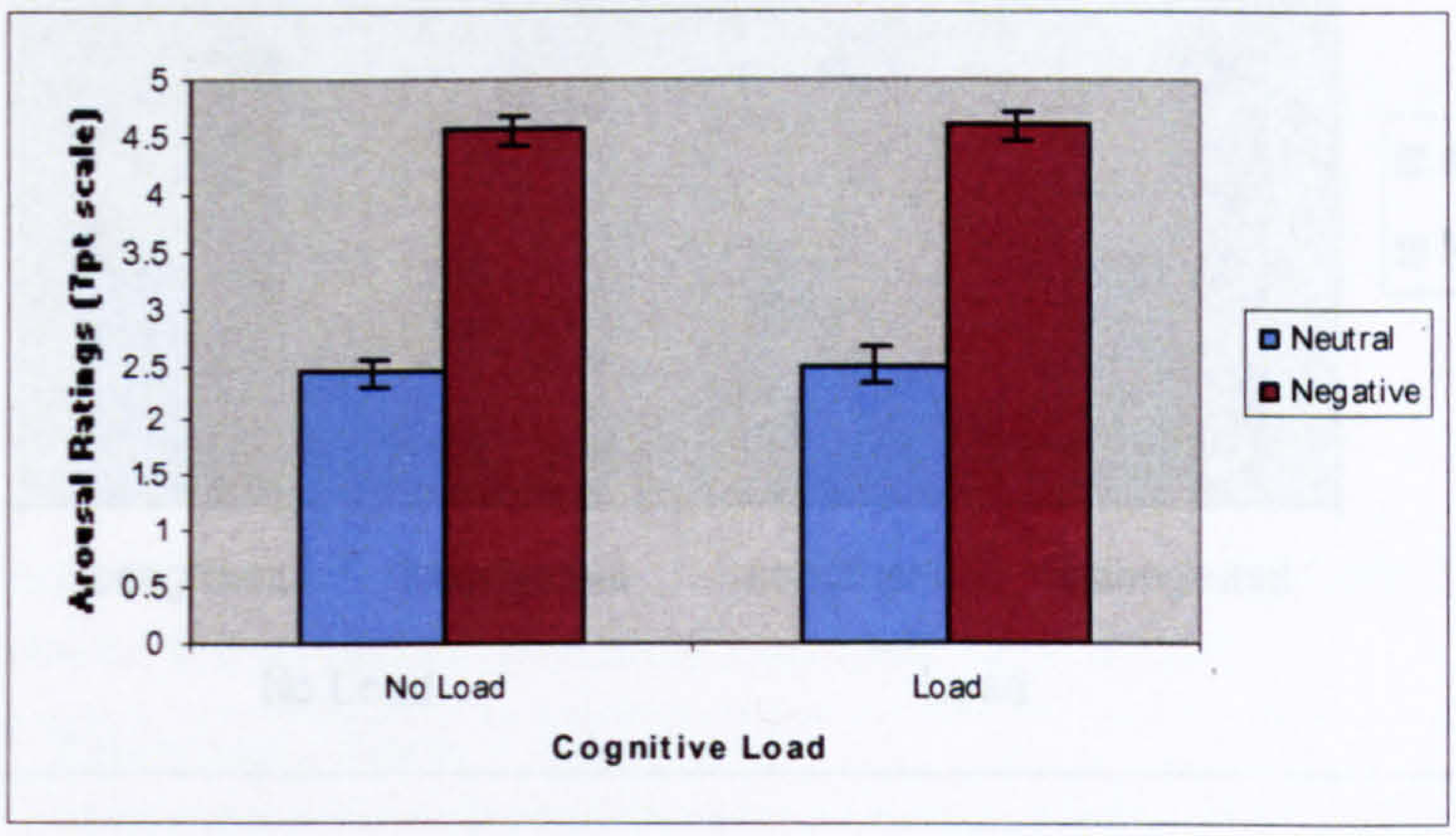


Figure 28: Self Reported Arousal Ratings for Negative and Neutral pictures in the No Load and Load conditions

There was, however, a significant Cognitive load x Congruence interaction ($F_{1,35} = 6.75$ $p < 0.02$ $d = .16$) with ratings for congruent pictures lower in the no load condition than the load condition (Means and SEs: 3.46, 11; 3.58,.12) and incongruent pictures higher in the no load than the load condition (Means and SEs: 3.53, .11; 3.50, .121). A Valence x Cognitive load x Congruence interaction ($F_{1,35} = 4.57$ $p < 0.04$ $d = .12$), however, showed that whilst ratings for both neutral congruent and incongruent pictures were higher in the cognitive load condition than the no load condition (Means and SEs = (Congruent) (load) 2.47, .16 (no load) 2.41, .14; (Incongruent) (load) 2.51, .16; (no load) 2.47, .13;), there was a difference in ratings for congruent and incongruent negative pictures in the no load condition.Ratings were higher for congruent negative pictures in the no load condition but lower for incongruent negative pictures in the no load condition, (Means and SEs = (Congruent) (load) 4.50, .14; (no load) 4.68, .13; (Incongruent) (load) 4.60,.14; (no load) 4.49,.14) (see Figure 29).

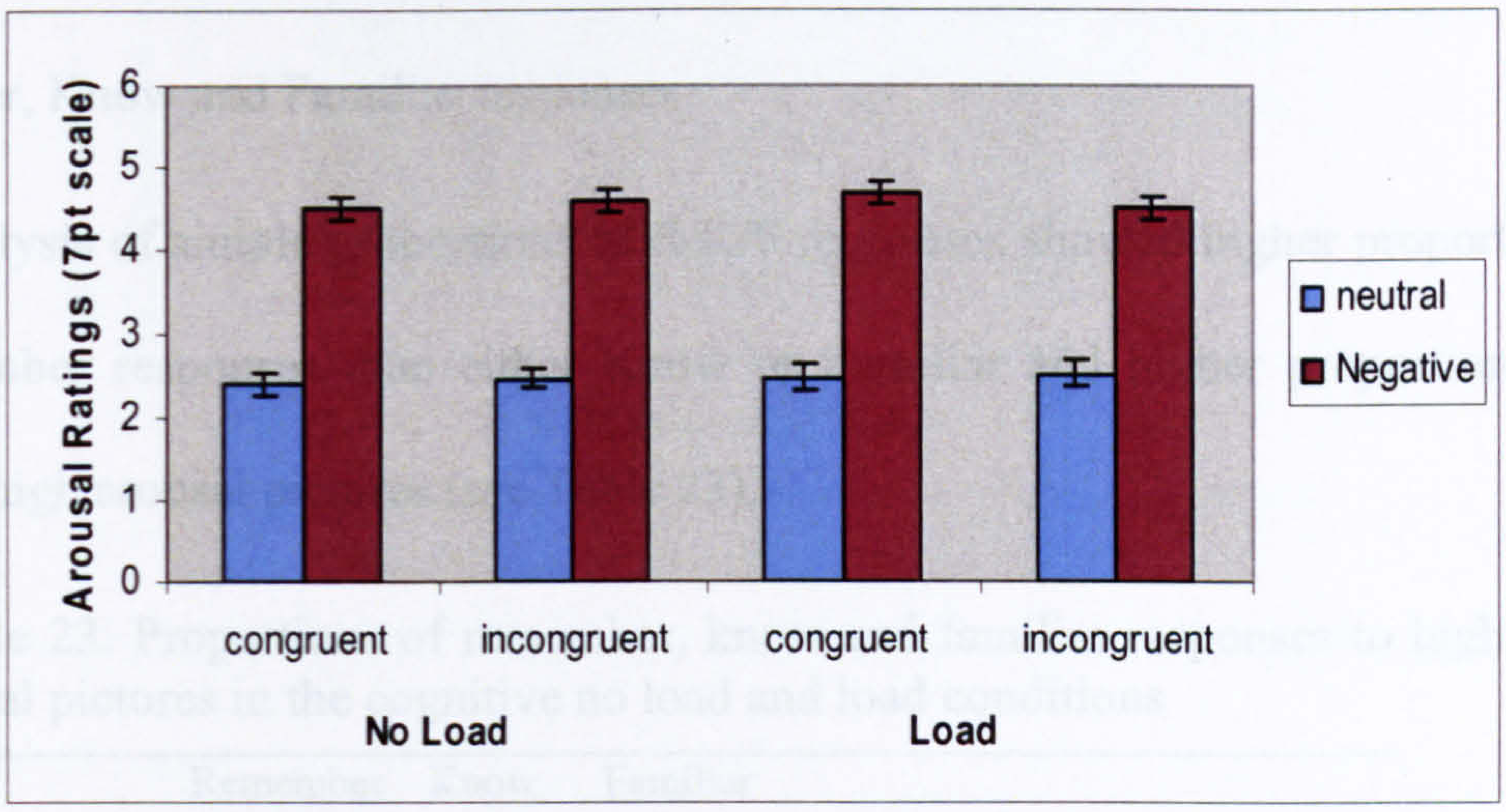


Figure 29: Self Reported Arousal Ratings for valenced congruent and incongruent pictures in the no load and load conditions.

1.1.6.3. Recognition Memory

Recognition Accuracy

Levels of recognition accuracy were again high. More high arousal than low arousal pictures were correctly recognised and there were few false alarm responses (see Table 22). One case was omitted from the analysis due to extreme scores and two outliers were adjusted following Tabachnick and Fidell (1997).

Table 22. Recognition accuracy data for negative and neutral pictures

Arousal	Hits	FAs	d'
High	.71	.04	2.13
Low	.65	.04	2.23

Statistical analysis of the d' measure showed no significant difference in d' for high and low arousal pictures ($t = 1.14$ $df = 35$ $*p > .05$).

Remember, Know and Familiar responses

Analysis of simple proportions of R/K/F responses showed higher proportions of Remember responses than either Know or Familiar and higher proportions of these for high arousal pictures (see Table 23).

Table 23. Proportions of remember, know and familiar responses to high and low arousal pictures in the cognitive no load and load conditions

	Remember		Know		Familiar				
Arousal	Hits	FAs	Hits	FAs	Hits	FAs	Recollection	Familiarity	d'
High	.49	.02	.08	.02	.14	.09	.83	.17	2.13
Low	.28	.03	.08	.02	.13	.06	.97	.03	2.23

A statistical analysis of simple proportions using a 2x2x3 ANOVA with arousal, cognitive load and recognition as the independent variables showed a main effect of arousal ($F_{1,34} = 5.96$ $p < .05$ $d = .15$) but no main effect of cognitive load ($F_{1,34} = 1.17$ $p > .05$). Again, more high arousal pictures than low arousal pictures were correctly recognised (Means and SEs = .24 (.01); .21 (.04)). There was also a main effect of recognition ($F_{1,34} = 81.62$ $p < .001$ $d = .71$) and an Arousal x Recognition interaction ($F_{1.58,53.8} = 3.21$ $p = .05$ $d = .09$). Remember responses were significantly higher than Know ($F_{1,34} = 92.08$ $p < .001$ $d = .73$) and Familiar responses ($F_{1,34} = 84.95$ $p < .001$ $d = .72$). Proportions of Know and Familiar responses were also significantly different from each other ($F_{1,34} = 10.05$ $p < .01$ $d = .32$) (see Figure

30). There was no Cognitive load x Recognition interaction (F<1) and no Arousal x Cognitive load x Recognition interaction (F<1).

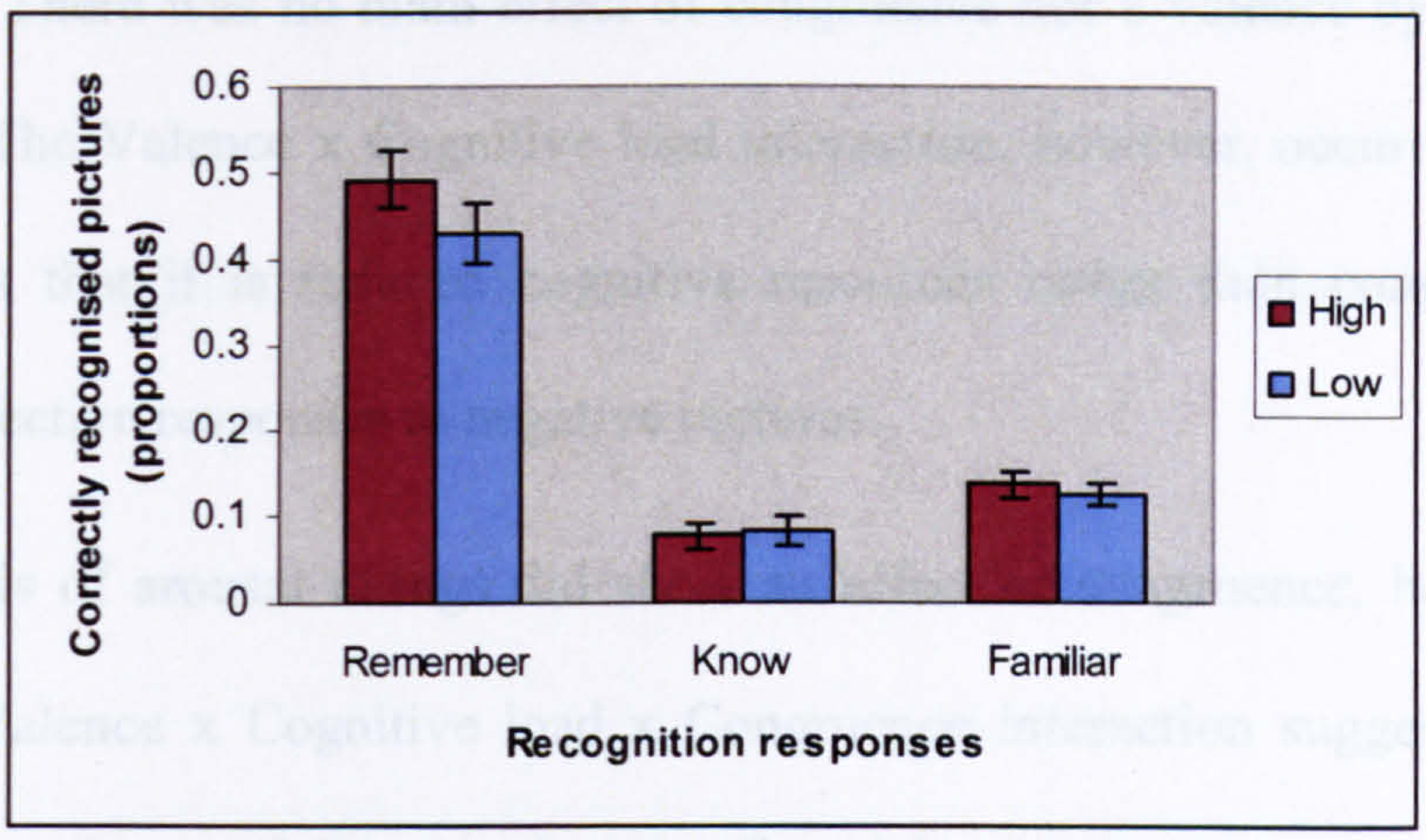


Figure 30. Proportions of remember, know and familiar responses for high and low arousal pictures

Recollection and Familiarity

Recollection was high for both low and high arousal pictures (see Table 23). Analysis of familiarity measures using a 2x2 ANOVA in which arousal and cognitive load were the independent variables showed no main effect of arousal (F<1), no main effect of cognitive load (F<1) and no Arousal x Cognitive load interaction ($F_{1,34} = 1.17$ $p > .05$).

1.1.7. Discussion

The experiment was designed to test the hypothesis that the reduction of cognitive resources and not the simultaneous processing of negative and neutral pictures produces attenuated emotional responses. Analysis of the experimental results showed that the valence by cognitive load interaction, with smaller startle magnitudes in the cognitive load condition, was not due to the manipulation of congruence. There was no main effect of congruence nor a valence by congruence interaction. The Valence x Cognitive load interaction, however, occurred yet again and suggests that it is reduced cognitive resources rather than congruence that modulate affective responses to negative pictures.

Analysis of arousal ratings did show an effect of congruence, however. The significant Valence x Cognitive load x Congruence interaction suggested that the conscious experience of the stimuli was affected by meanings constructed and the sequence in which the pictures were presented. Thus, holding a negative picture in mind had an enhancing effect on the rating of a subsequent negative picture and holding a neutral picture in mind dampened the experience of a subsequent negative picture.

1.1.8. Summary

To summarise, manipulations of congruence had no effect on startle magnitudes but produced a significant interaction between valence, cognitive load and congruence on arousal ratings, with neutral distractor pictures dampening the affective response to a following negative picture. By contrast, manipulation of cognitive load had an effect on startle magnitudes with a dampening of negative affect in the cognitive load condition but no effect on arousal ratings. It was concluded that congruence may have an effect on conscious experience but not on unconscious affect generation. It was concluded that reduced cognitive resources modulate affective responses.

Part III

Implications, Applications and Further Research

Chapter 8

Making Sense of the Evidence

1.0 Summary

1.1 Cognitive mechanisms and emotion regulation

1.1.1. Summary and Results

This thesis is a report of an experimental investigation into the cognitive mechanisms that underlie emotion regulation. Five studies were conducted on the cognitive control of emotion. Two studies investigated the effects of direct conscious and intentional control on both self-report and psychophysiological measures of emotion. Next, three studies investigated the effects of dividing cognitive resources on the emotional startle eyeblink paradigm. More specifically, Experiments 1 and 2 manipulated a potential effect of conscious and intentional control via an instruction to feel or not feel emotional responses to emotion generating pictures. Experiments 3, 4 and 5 tested the effect of a concurrent working memory task on the emotional startle paradigm. Emotional and neutral pictures from the International Affective Picture system (Bradley et al., 1999a, Lang et al., 2001) and Google images validated on the experimental population were used to generate emotions.

In experiments 3-5, cognitive resources were manipulated using a working memory task that required participants to hold words or pictures in mind whilst viewing and rating emotion generating pictures. The results were compared with a control condition with no working memory task. Two independent cognitive modalities were tested: verbal (words) and non-verbal (pictures). Memory for black and white standardized faces were used specifically to manipulate cognitive resources used for visual processing, and memory for words were used to activate verbal processing and to replicate the experiment using a different type of material. In addition, experiment 5 aimed at testing an alternative explanation for the effects of cognitive load. It could be argued that holding in mind a neutral picture while viewing an emotional picture "dilutes" the emotional content of the picture being viewed. In other words, the emotional content of the picture being viewed is diminished because a non-emotional image is being held in mind and provides the possibility for participants to focus their attention on an internal neutral image rather than on the emotional picture. Thus the neutral image being held in mind would provide an opportunity of reappraisal (through detachment, see Gross, 1998). Therefore, any effect of a decrease of emotional responses during a cognitive load condition could be attributed to a "dilution" of the emotional content rather than by an effect of cognitive load *per se*. Therefore, experiment 5 manipulated the valence of pictures held in mind during a concurrent working memory task. The crucial condition was when the picture held in mind was congruent with the picture being viewed (i.e. both were negative IAPS pictures). A "dilution" process would not be possible here, because both image and picture are negative.

Two measures of emotional responses were taken: physiological measures and self reported arousal ratings. In experiments 1 and 2, HR, GSR and corrugator supercilii activity were the selected physiological measures. The emotional startle paradigm was used in experiments 3-5. This paradigm uses a loud noise (i.e. the acoustic startle) to generate an eyeblink response that is known to covary with affective responses. Thus, when viewing negative pictures, eyeblink magnitudes are larger than when viewing neutral pictures and so provide a measure of emotional response.

1. 1. 2 Cognitive mechanisms and emotion regulation: the results

No evidence of an effect of conscious and intentional control on HR or GSR was found in experiments 1 and 2. Corrugator supercilii activity and self reported arousal ratings did respond, however, with higher supercilii magnitudes and higher arousal ratings in the feel than the no feel conditions.

In experiments 3-5, a classical emotional startle effect was obtained in a control condition (no working memory load). However, it was found that a reduction of cognitive resources reduced the emotional startle effect. This effect was found in all three experiments, attesting to the robustness of this phenomenon. Furthermore, no effect of congruence was found in experiment 5 to challenge the results: Working memory load dampened the emotional startle effect even when negative emotional pictures were used for the working memory task, and thus rules out the alternative explanation that results from experiments 3-4 might be explained by re-appraisal opportunities provided by the neutral pictures used in the concurrent task.

1.1.3 Study Limitations

From the results of experiments 3-5, it is clear that there is compelling evidence that cognitive resources are required for the generation of fast emotional responses to negative pictures. What is still unclear is the exact nature of those resources. Resources used to hold in mind both verbal items (i.e. words) and non-verbal items (i.e. pictures) whilst viewing and rating negative pictures for levels of arousal produced attenuated emotional responses. However, what is unclear, and in need of further research to clarify, is the exact nature of those resources. It is possible, for example, that such resources are required for the visual attention Pessoa claims is required for emotion generation (Pessoa et al., 2005a, Pessoa et al., 2002a, Pessoa et al., 2002b, Pessoa and Ungerleider, 2004), or that emotional responses may be inhibited when resources are required for demanding cognitive tasks (Pessoa et al., 2005b).

In experiment 4 (with verbal items for the working memory task), participants were free to use both verbal and visual processing to hold a word in mind ready for the subsequent word matching task. Both types of processing were possible, therefore. Thus, though the fast speed of the modified emotional startle suggests that *conscious* visual attention is not an appropriate explanation, visual attention may be required. This is discussed further in the next section.

To establish the exact nature of the cognitive resources used, future experiments would need to separate visual from verbal processing to verify attenuated emotions and a modality independent effect. The indications are that since the size of the attenuation effect was reduced when using words compared with the effect size obtained when using pictures, it is possible that the function of cognitive processing is to maintain visual processing. Though further research is required to produce a definitive conclusion, the evidence that cognitive resources are required for the generation of emotion offers strong support for Pessoa's claim that emotion generation involves *cognitive modulation* (Pessoa et al., 2005b).

With reference to experiments 1 and 2, and attempts made to study the effects of conscious and intentional control on emotional responses, it is acknowledged that the use of the acoustic startle would have provided a more sensitive measure of emotional response than either HR or GSR and may have produced more interesting results. It is also regretted that more time was not available to pursue the effect of attenuated emotion in recognition memory found in experiment 1 but not replicated in experiment 2. It is possible that failure to replicate the result could have been due to difficulties participants in a within subjects design may have had switching from a feel to a no feel instruction and vice versa. Interactions between top-down emotion regulation and bottom-up stimulus driven generation are hot topics in current research (Vuilleumier, 2005) and investigating a potential link between conscious and intentional control and degrees of engagement of the self in a picture viewing activity manipulated by instructions, might generate interesting results.

1.1.4 Cognitive resources, attention and emotion generation

Though the limitations outlined above are acknowledged, the conclusion that strong evidence exists to show that reducing cognitive resources can dampen emotional responses to external stimuli is a major contribution to an understanding of emotion generation. To my knowledge, it is the first time that the need for cognitive resources to elicit the emotional startle effect has been demonstrated and is, potentially, a useful contribution to current research.

In recent years, the old Lazarus versus Zajonc debate over the role of cognitive processing in emotion generation has resurfaced in attention research. Debate over the role of pre-attentive and post-attentive processing of visual stimuli and the generation of emotional responses is on-going and producing conflicting evidence. Whilst Vuilleumier consistently produces evidence to support the pre-attentive position (Vuilleumier, 2005, Vuilleumier et al., 2001a, Vuilleumier et al., 2001b), Pessoa's results consistently support post-attentive processing (Pessoa et al., 2005a, Pessoa et al., 2002a, Pessoa et al., 2002b). Pre-attentive processing refers to low level automatic perceptual scanning of the environment independent of cognitive resources and focused attention. Post-attentive processing, on the other hand, requires focused attention and cognitive resources to guide the processing of selected stimuli. By claiming evidence of post-attentive processing of emotional generating stimuli, Pessoa is also claiming that emotional responses require attentional resources. In fact, he maintains that during demanding cognitive tasks, the limbic system may be deactivated and produce a form of emotional blunting (Pessoa et al., 2005b).

Attempts to reconcile the evidence is currently based on questioning methodology. For instance, criticisms include the validity of masking speeds used to test pre-attentive processing, and concerns over attentional capacity in a focused attentional task which, if not fully utilized, may leave spare capacity for peripheral scanning and processing of the peripheral visual field thought to be processed pre-attentively (Pessoa et al., 2005a, Pessoa et al., 2002b). Though the studies reported in this thesis did not clarify the exact role of cognitive processing in emotion generation, they do offer potential support for Pessoa's claims that emotion generation is not pre-attentive and cognitively independent, and furthermore, do so from a different paradigm with a different approach and methodology.

The emotional startle paradigm differs from fMRI studies, such as those by Vuilleumier and Pessoa, by offering unequivocal evidence of emotion modulation.

Whilst fMRI can successfully identify changes in amygdala activation during the processing of emotion generating stimuli, the amygdala is known also to function to produce orienting responses (Öhman and Mineka, 2001) and to increase activation during effortful cognitive processing tasks (Schaefer et al., 2006). Thus amygdala activation identified by fMRI studies cannot be unambiguously attributed to emotion modulation. The emotional startle, however, is a direct and unequivocal measure of affective response (Bradley et al., 1990). In addition, it is also an extremely fast response, with an onset latency of <100ms. Therefore, it is believed to be largely automatic (Lang et al., 1998, Vrana and Lang, 1988).

At the heart of the Vuilleumier versus Pessoa debate is the problem of automaticity. Traditionally, emotion generation is believed to be automatic. That is, emotional processing is thought to be independent of higher order cognition and extremely rapid. An exciting contribution that use of the emotional startle can add to the debate is to confirm the rapidity of the emotional response but to seriously question cognitive independence. In addition, an important implication of this is that emotional responses cannot have been generated solely by the fear cascade circuitry described by LeDoux (1996). Though snakes and spiders, loud noises, sudden movement and changes in luminance may trigger response tendencies, pictures of such stimuli, minus accompanying sound and movement, may not. According to LeDoux, emotional responses generated by the fear circuitry engage sub-cortical mechanisms to generate the response. Visual stimuli automatically trigger cells in the thalamus that activate the amygdala and the fear cascade that increases heart rate, respiration and glucose production in readiness for a fast behavioural response. The process is totally independent of cognitive mechanisms. If pictures of threat related stimuli used the same mechanisms to generate emotional responses, then they would be generated regardless of any concurrent working memory task and would not produce attenuated emotional responses. However, emotional responses were generated and attenuated. Higher startle magnitudes produced whilst viewing negative compared with neutral pictures is well documented evidence of emotion generation (Bradley et al., 1988, Bradley et al., 1990, Bradley et al., 1993a, Bradley et al., 1999b, Bradley and Lang, 2000, Lang et al., 2000). It would seem, therefore, that passive viewing of negative and threat related pictures generates rapid emotional responses but not independent of higher order cognition. Either such stimuli do not use the fear circuitry described by LeDoux, or, for humans at least, the circuitry is not as entirely independent of cognitive resources as LeDoux maintained. To conclude, it would appear that top-down influences on emotional responses is much more important than previously thought.

1.1.5 Resource dependence and emotion regulation

The role of cognitive resources in emotion generation identified in this study also suggests potential implications for emotion regulation. Specifically, it might be possible that division of cognitive resources might account for at least part of the effectiveness of usual emotion regulation strategies. For example, it is possible that the division of cognitive resources between current appraisal and concurrent re-appraisal of the same stimulus during cognitive reappraisal tasks (Gross, 1996, Gross, 1998a, Gross, 2002, Gross and Levenson, 1997b, Jackson et al., 2000, Ochsner et al., 2004) could *in part* explain attenuated emotional responses regardless of appraisal determined changes. Similarly, therapies that require trauma sufferers to remember and describe specific traumas in detail (Philippot et al., 2003) again may reduce emotional responses, at least in part, by reducing cognitive resources available for generating the emotion. Eye Movement Desensitization Reprocessing (EMDR) may also operate successfully in a similar way and perhaps even more directly. EMDR requires trauma victims to recount the details of a traumatic experience whilst tracking a moving object e.g. a finger. Thus cognitive resources required to activate visual images from memory and track a visual object in real time may also result in attenuated emotion.

The success of therapies may be due to enabling changes to occur in memory. Joseph LeDoux maintains that emotional responses to past events are not stored in memory but generated anew each time the memory is activated (LeDoux, 1996). Thus, memory of being bitten by a dog, for example, may generate feelings of fear that were experienced at the time of the event but that are generated and experienced again in real time. Reducing cognitive resources at the time of *remembering* an event may reduce resources for the renewed emotional response and thus activate an attenuated form compared with the original experience. If current circumstances did not increase the intensity of the response, then the current experience and subsequent memory may be attenuated.

Implications for trauma prevention is also a possibility. Training emergency service personnel to focus on well-rehearsed procedures and resist temptations to focus on visual evidence of physical trauma may also divide resources and attenuate emotional responses. Research by Emily Holmes in which participants were required to divide attention between a fear generating film and an attention tapping task found that subsequent intrusive memories of the film one week later were fewer for the tapping task group than the control group (Holmes, 2004). It is possible that such results may be explained, again, via the effects of reducing cognitive resources.

Emotion generation and regulation, however, are subject to both bottom-up stimulus driven mechanisms and top-down executive functions (Vuilleumier, 2005). Any simplistic explanation of the processes involved is not proposed. What is suggested is that emotion generation requires cognitive resources to generate emotional responses to static, visual images and that such processes may operate in real life situations and may be relevant to both emotion generation and regulation. Much further research is required to test the potential implications of the results of this study outlined above.

1.2 Recognition Memory

1.2.1 Summary, results, limitations and conclusions

As a secondary task, not relevant to the main thrust of the thesis and having no bearing on the main conclusions of the study, was a surprise recognition memory task that followed each experiment. This was undertaken to maximise the experimental opportunity and perhaps produce exploratory material that could potentially provide useful material for future research. In this task, participants were required to look at a randomised selection of old and new pictures (pictures previously seen in the experimental task and unseen pictures) and record whether or not they had seen them in the experimental programme. If recognised, pictures were then marked as remembered, known or familiar. The data collected was analyzed to compare remember and know responses using the R/K paradigm and estimates of underlying recollection and familiarity processes. Familiar responses were used to indicate confidence levels. The overlap between recollection and familiarity responses (Jacoby, 1991) was addressed using the formula $((k/n)/(1-(r/n)))$ (where k = know responses, r = remember responses and n = the total number of possible responses). Response confidence for remember and know responses (Yonelinas, 2001) was controlled via instructions (see Appendix 1). Recognition accuracy was measured via signal detection d' for valence and arousal generally.

Interpretations of the results showed some support for existing research and offered interesting lines for future investigations. For example, higher recognition accuracy was found for neutral than either negative or positive pictures, consistent with Maratos, Allan and Rugg (Maratos et al.)and Leiphart, Rosenfeld and Gabrieli (Leiphart et al.). However, these results were inconsistent with Ochsner (2000) who found high recognition accuracy for emotional compared to neutral pictures. Such contradiction on the effects of emotion on recognition accuracy are frequent (Kensinger and Schacter, 2008) Analysis of remember, know and familiar responses showed that negative pictures were more frequently remembered than positive pictures. High arousal pictures were also more frequently remembered than low arousal pictures in all experiments. This finding is in line with consensual findings in literature (e.g. (Ochsner, 2000, Sharot et al., 2004)). Recollection and familiarity showed similar patterns and again paralleled the findings of Ochsner (2000). As a function of valence, recollection was greatest for negative pictures. As a function of arousal, recollection was also greater for high arousal than low arousal pictures.

Manipulating cognitive resources actually produced higher levels of recollection when resources were reduced in experiments 3 and 4 but there was no effect of arousal suggesting, perhaps, an effect of increased effort. There was no effect of recollection in experiment 5, however, where levels of uncertainty, made visible by a high proportion of familiar responses, were higher than in either of the two previous experiments. It was thought that increasing the number and similarity of pictures whilst controlling response times had probably made recollection of specific pictures more difficult for both high and low arousal pictures.

Relevant to this study, was the finding that apart from experiment 1, there was no evidence of any Task x Memory x Emotion interaction. It would appear that manipulating cognitive resources at encoding did not have an effect on the modulation of emotion in memory. It must be re-emphasised, however, that the recognition memory task was only undertaken as a secondary and exploratory task and a number of design limitations need to be addressed in future research before any firm conclusions can be drawn. For example, recognition accuracy overall was high (e.g. d' values above 2.0) and was probably the result of too short a delay between the experimental and recognition memory task. Consistent with this explanation, Sharot & Yonelinas (2008) found that the emotional modulation of recollection is a time-dependent process and, in general, no effect of emotion on recollection is found when using a recognition test immediately after the study stage. Required similarities between pictures in experiment 5, in particular, may have primed distinctiveness processing, and this, together with higher arousal levels for experimental pictures than foils, may well have produced an inflated bias towards remembered pictures. In addition, though participants were fully versed in the requirements of the R/K paradigm, they were not required to practise before undertaking the task and sufficient evidence of their use of the paradigm was not taken to verify all the responses. Further research that addressed these issues and fully explored both the R/K paradigm and recollection and familiarity processes might develop and expand upon the potential effect of conscious and intentional control on emotional responses with interesting results.

1.3. Conclusions and further research

Two major conclusions can be drawn from this study. Firstly, there appears to be valid evidence that cognitive resources are required for the generation of emotional responses to negative pictures, and secondly, that such evidence suggests that emotion generation may be rapid but not entirely automatic. Implications for an understanding of emotion are both theoretical and practical. Definitions of emotion as an automatic reflex may require qualification perhaps with reference to specific circumstances, types of stimuli in question or with reference to specific emotion generating mechanisms. It is also suggested that practical applications of these results may usefully contribute to trauma prevention procedures and an understanding of therapies designed to reduce the emotional effects of trauma.

It is acknowledged, however, that further research is required to address new questions that this study poses. For example, research is required to test the nature and possible modality independence of the cognitive resources involved in generating emotional responses to negative pictures. Phonological rehearsal of rhyming words or the maintenance of simple melodies (e.g by using the tonic sol-fa scale) as a concurrent working memory task whilst viewing and rating emotion generating pictures, might provide more stringent control of visual processing. Studies designed to investigate emotion generating mechanisms, to identify sources of activation, and to test for possible differences due to different types of stimuli (e.g. static, visual images versus sound and movement cues in films) would be a further development as would experiments undertaken to discover *exactly* how much of any emotion regulation strategy could be attributed to resource division alone. Finally, it is also felt that the effects of a conscious and intentional instruction to feel and not feel emotional responses should be fully explored in order to investigate indications that such control *may* dampen emotionality in memory. It is believed that such experiments should be repeated with the acoustic startle as a fast and sensitive measure of emotional response and with EEG or fMRI equipment to identify sources of activation and changes in response. If emotional attenuation is replicated, then further research might, perhaps, usefully explore an engage/disengage instruction to indicate whether or not the mechanism involved might operate according to self relevance.

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Appendix 1

Experiments 1 and 2: Instructions

Condition 1: Feel

This programme will show you a selection of pictures

They will be presented one at a time and remain on the screen for 6 seconds

Your task is to Look at each picture and Rate how strongly you respond to each one

Use this scale to rate your responses

Very Weak 1   Weak 2   Moderate 3   Strong 4   Very Strong 5

Press a number on the response pad to register the STRENGTH of your response

(Register your First response as quickly as you can but Continue to Look at the picture for all 6 seconds

Ignore the nature of your response which may be positive or negative

i.e. You may feel very strongly positive or negative but the response is still 5

Only the STRENGTH is important)

When requested to do so, Press any Key to Start the programme.

<u>Condition 2:</u> <u>No Feel</u>

This programme will show you a selection of pictures

They will be presented one at a time and remain on the screen for 6 seconds

Your task is to Look quickly at each picture and

Stop the emotional response (i.e. Don't feel it/ Control it)

Then Rate the strength of any response that you still have.

Use this scale to rate your responses

Very Weak 1 Weak 2 Moderate 3 Strong 4 Very Strong 5

Press a number on the response pad to register the STRENGTH of your response

Register your FIRST response as quickly as you can but Continue to Look at the picture for the full 6 seconds.

Concentrate on the STRENGTH of the remaining response not the nature

(i.e. ignore whether it is positive or negative only the STRENGTH is important)

When requested to do so, Press any Key to Start the programme.

Experiment 3: Instructions

Conditions 1 and 2: No Load and Load

INTRODUCTION

In this study there are 2 activities and 3 tasks within each activity.
Each task lasts no-longer that approximately 5 minutes
(15 minutes per activity)
You are requested to keep as still as you can whilst engaged in a task.
The purpose of the study is to measure your responses to pictures and not to measure muscle activity resulting from movement.

All tasks require you to register the strength of your responses to the pictures presented on the computer screen and to complete an additional task involving faces. The face tasks require you to make decisions regarding whether a face is a male or a female face and whether a face matches a face shown previously in the task. The face tasks for the two activities are different but the tasks *within* each activity are the same i.e. the faces change but the instructions remain the same.

THE PICTURES

The computer programme will show you a selection of pictures.
They will be presented one at a time and remain on the screen for 5 seconds.
Your task is to look at each picture and rate how strongly you respond to each one.
(Ignore whether your feelintgs are positive or negative.
Only the strength of the feeling is important.)

(Example given for cat lovers and allergy sufferers)
Rate the STRENGTH of the feeling you have when you FIRST see the picture.
Rate what you ACTUALLY feel **at that moment in time**, NOT what you think you 'should' feel.
(Example given for someone beating the cat)
Use this scale to rate your responses:

0	1	2	3	4	5	6
I feel nothing at all						I feel extremely strong emotions

When the scale appears on the screen, Press the number on the response pad that best registers how strongly you feel. You have a maximum of 2 seconds in which to respond. The scale will disappear when you press a key or after 2 seconds – whichever is the sooner.

The Faces

No Load Activity

This activity presents a sequence of 4 screens a number of times.

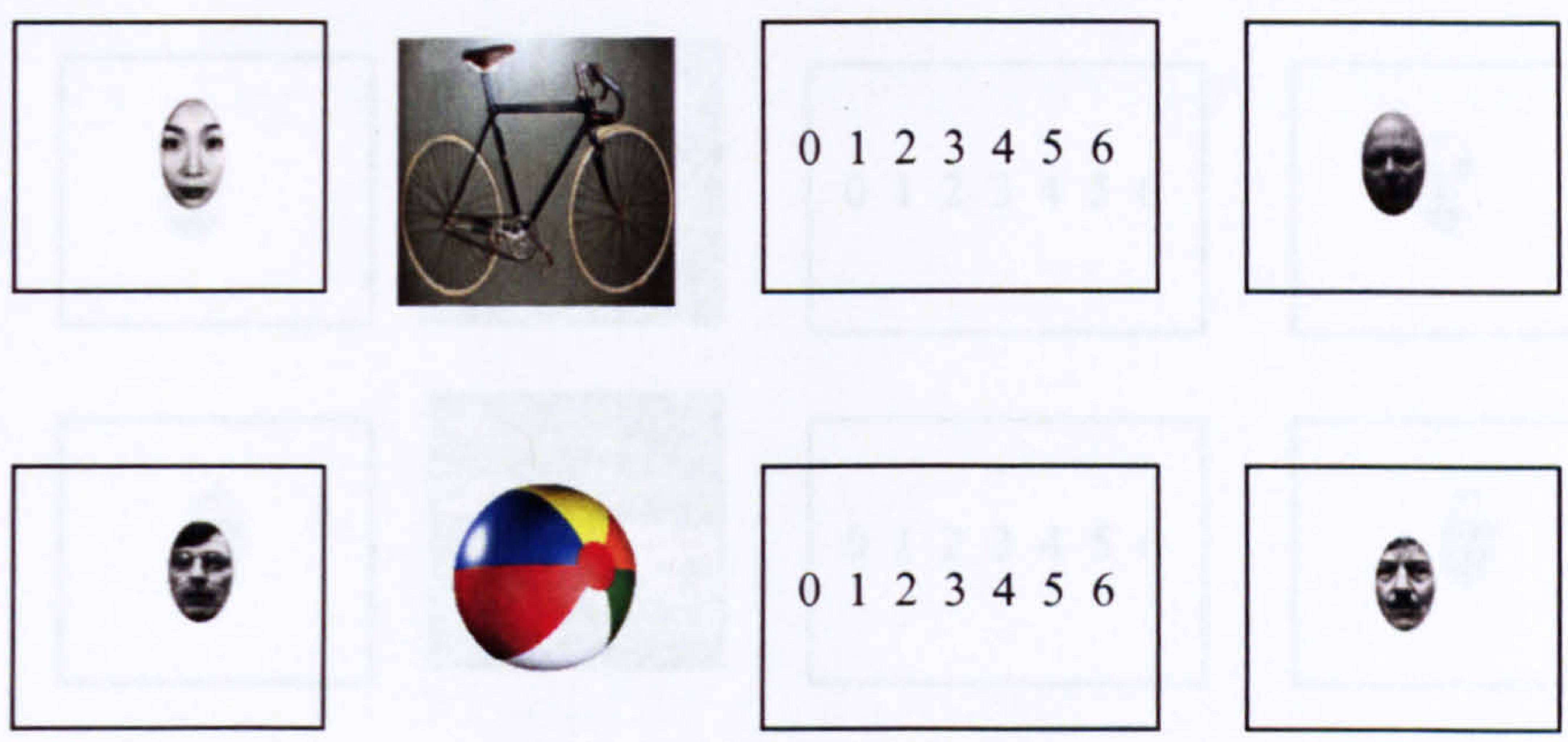
Each sequence consists of a face a picture, a rating scale and another face.

You have two instructions to follow:

1. Rate your responses to the pictures

2. Register whether a face is a male face or a female face.

Example:



i.e.

1. Look at the picture and Feel your response.
2. Rate the Strength of your Feeling when you see the rating scale.
3. Look at the faces when they appear.
4. Press a key to register Male Face or Female Face:

   Blue Key: Male   Red Key: Female

5. Repeat the procedure to complete all sequences in the first and subsequent two tasks.
6. At the end of each task, Press any key to start the next.
7. Stop at Task 3 End.

   (We will take a break, revise and practise the next activity)

N.B. Participants were told that they would not have to remember all the instructions as we would practise the tasks until they could do them satisfactorily.

The Faces

Load Activity

This activity presents a sequence of screens repeated a number of times. Each sequence consists of a face, a picture, a rating scale and another face. You have two instructions to follow:

1. Rate your responses to the pictures.
2. Register whether the face AFTER the picture is the SAME or DIFFERENT from the face immediately BEFORE the picture.

Example:

i.e.

1. Look at the face and remember it.
2. Look at the picture and Feel your response.
3. Rate the Strength of your Feeling when you see the rating scale.
4. Look at the next Face that appears and Press a key to register: Same or Different

   Blue Key: Same Red Key: Different
5. Repeat the procedure to complete all sequences in the first and subsequent two tasks.
6. At the end of each task, Press any key to start the next.
7. Stop at Task 3 End.

   (We will take a break, revise and practise the next activity)

N.B. Participants were told that they would not have to remember all the instructions as we would practise the tasks until they could do them satisfactorily.

Instructions for Remembering the Faces

The face matching tasks are designed specifically to study *visual* working memory. It is important, therefore, to store *visual images* of the faces whilst rating your responses to the pictures. To do this, use the following strategy:

- Look at the face on the screen and visualise it in your head.
- Look at the picture and feel your response (but keep visualising the face in your head to maintain the memory)
- Register the strength of your response to the picture.
- Conjure up the image of the first face and Match it to the next face that appears on the screen.
- Register SAME (blue) or DIFFERENT (red) on the response pad.

Experiment 4: Instructions

The information and instruction sheet used in Experiment 3 (**Introduction** and **The Pictures**) was used again to explain the task requiring emotion ratings to pictures. Instructions for the cognitive manipulations were as follows:

The Words
No Load

This activity presents a sequence of 3 screens a number of times.
Each sequence consists of a picture, a rating scale and a word or non-word.
You have two instructions to follow:
1. Rate your responses to the pictures.
2. Register whether a string of letters is a word or non-word.

Example:

STAMP

0 1 2 3 4 5 6

NAIL

0 1 2 3 4 5 6

PRITTI

i.e.
1. Look at the picture and Feel your response.
2. Rate the Strength of your Feeling when you see the rating scale.
3. Look at the letters when they appear.
4. Press a key to register Word or Non-word.

   Blue Key: Word Red Key: Non-word
5. Repeat the procedure to complete all sequences in the first and subsequent two tasks/
6. At the end of each task, Press any key to start the next.
7. Stop at Task 3 End.
   (We will take a break, revise and practise the next activity)

N.B. Participants were told that they would not have to remember all the instructions as we would practise the tasks until they could do them satisfactorily

The Words
Load Activity

This activity presents a sequence of screens repeated a number of times. Each sequence consists of a word, a picture, a rating scale, and another word.

You have two instructions to follow:

1. Rate your responses to the pictures.
2. Register whether the word AFTER the picture is the SAME or DIFFERENT from the word immediately BEFORE the picture.

Example:

BALL

0 1 2 3 4 5 6

BALL

0 1 2 3 4 5 6

PIPE

i.e.

1. Look at the Word and remember it.
2. Look at the picture and Feel your response.
3. Rate the Strength of your Feeling when you see the rating scale.
4. Look at the next Word that appears and Press a key to register: Same or Different: Blue Key: Same Red Key: Different
5. Repeat the procedure to complete all sequences in the first and subsequent two tasks.
6. At the end of each task, Press any key to start the next.
7. Stop at Task 3 End.
   (We will take a break, revise and practise the next task)

N.B. Participants were told that they would not have to remember all the instructions as we would practise the tasks until they could do them satisfactorily.

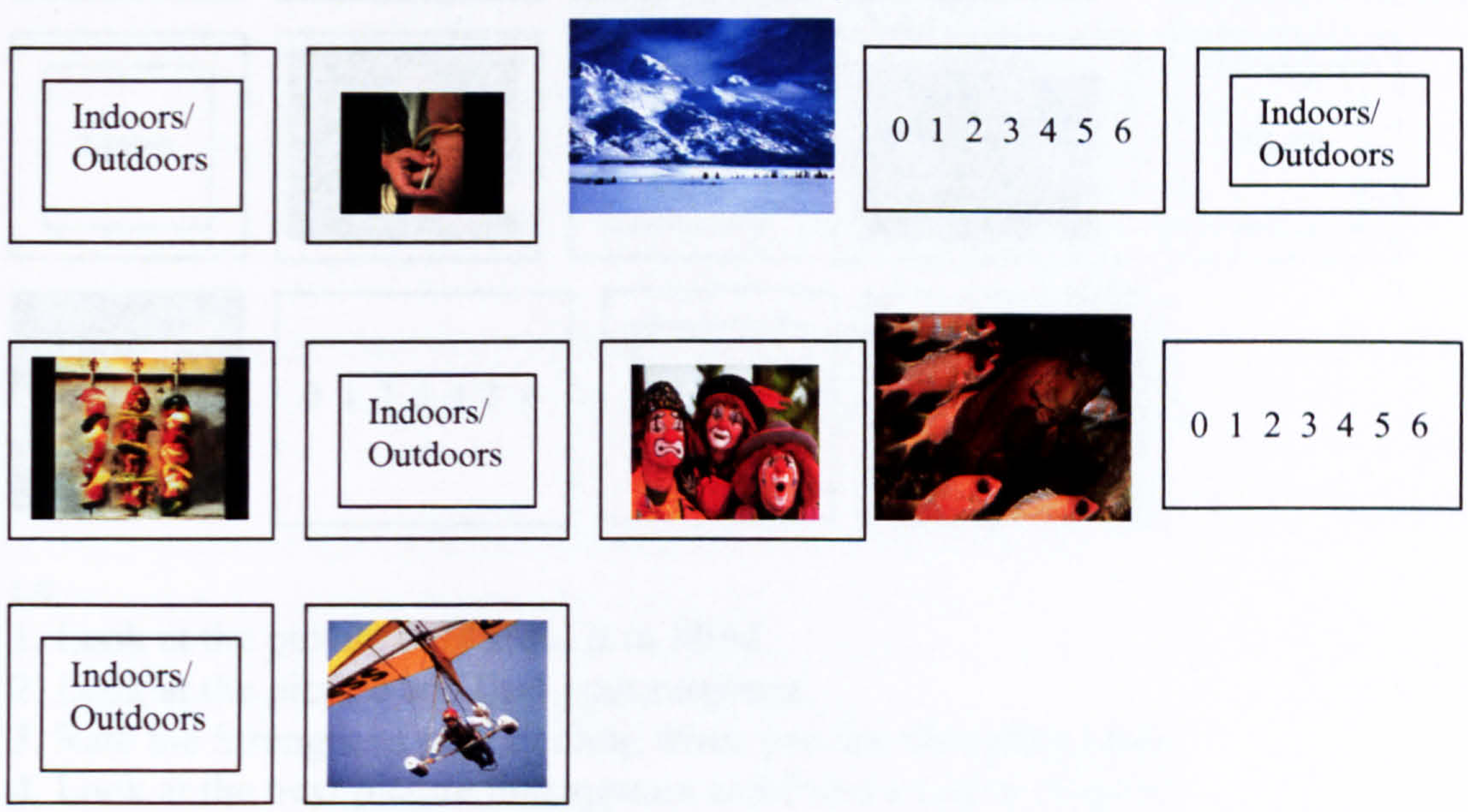
Experiment 5: Instructions

The information and instruction sheet used in Experiment 3 (**Introduction** and **The Pictures**) was used again to explain the task requiring emotion ratings to pictures. Instructions for the cognitive manipulations were as follows:

Outdoors/Indoors
No Load

This activity presents a sequence of 4 screens a number of times.
Each sequence consists of a decision picture, another picture, a rating scale and a decision picture.
You have two instructions to follow:
1. Rate your responses to the pictures
2. Register whether a scene or object is Indoors or Outdoors.

Example:



i.e.
1. Look at the 1st picture when it appears
2. Press a key to register Indoors or Outdoors:
   Red Key: Indoors Blue Key: Outdoors
3. Look at the next picture and Feel your response
4. Rate the Strength of your Feeling when you see the rating scale
5. Look at the 2nd decision picture and register Indoors/Outdoors
6. Repeat the procedure to complete all sequences in the first and subsequent two tasks
7. At the endof each task, Press any key to start the next
8. Stop at Task 3 End
   (We will take a break, revise and practise the next activity)

N.B. Participants were told that they would not have to remember all the instructions as we would practise the tasks until they could do them satisfactorily.

Same/Different
Load Activity

This activity presents a sequence of screens repeated a number of times. Each sequence consists of a study picture, a second picture, a rating scale and a test picture.

You have two instructions to follow:

1. Rate your responses to the pictures.
2. Register whether the picture AFTER the rating scale is the SAME or DIFFERENT from the first picture in the sequence.

Example:

i.e

1. Look at the picture anfd Hold it in Mind.
2. Look at the picture and Feel your response.
3. Rate the Strength of your Feeling when you see the rating scale.
4. Look at the next picture that appears and Press a key to register:
   Same or Different: Blue Key: Same   Red Key: Different
5. Repeat the procedure to complete all sequences in the first and subsequent two tasks.
6. At the end of each task, Press any key to start the next.
7. Stop at Task 3 End.
   (We will take a break, revise and practise the next activity)

N.B. Participants were told that they would not have to remember all the instructions as we would practise the tasks until they could do them satisfactorily.

Recognition Memory Task: Instructions

At the end of the computer activity participants were told that before the electrodes were removed, they were required to look at several pages of pictures and see if they recognised any of them as having been in the programme they had just taken part in. If they recognised a picture, they should try to work out how they recognised it i.e.

If they *remembered* the picture coming up on the screen, or they remembered a particular part of the picture, or something they remembered thinking about at the time, (i.e. they had some evidence in their heads to 'prove' that the picture was in the programme) they should write the letter R on the acetate covering that picture.

If they *Knew* that the picture was in the programme but had no mental evidence as such to prove it, they just *Knew* it was there, then they should write the letter K on the acetate over that picture.

If the picture looked familiar so it probably was in the programme but they weren't really sure..... It was *familiar* so it probably was ... then they should write the letter F on the acetate over that picture.

The following **written** instructions were then placed in front of the participant so that they could refer to them if necessary as they looked at the pictures.

Instructions

1. Please look at the laminated picture sheets and identify the pictures you recognise as having been in the programme you've just taken part in.
2. Using the definitions below, write the letter that best corresponds with your personal experience of recognizing the picture:

R = When you saw the picture you had an experience of **Remembering** it. This could have included seeing the picture in your mind's eye, Remembering what you thought or pictured when you saw the picture on the computer screen, and/or having a sense of yourself in the past.

K = When you saw the picture you simple **Knew** that it had been on the Computer without any of the other feelings associated with vividly Remembering that you had seen the picture before.

F = When you saw the picture you had a feeling of **Familiarity** with the picture and because of that you thought that the picture had been on the computer.

Appendix 2

Categories for Selected Pictures

Experiment 1	Negative	Positive	Neutral
	Accidents (e.g.road accidents) Aggression (e.g. attacks on people) Death and Disease (in humans and animals) Contamination (e.g. food and insects) Mutilation (e.g. facial and body disfigurement) Distress (e.g. a sad or starving child) Human waste (e.g. excrement and vomit)	Romance (e.g. happy couples) Animals (e.g. seal pup) Young people (e.g. children and pets, happy teenagers) Nature and Landscapes (e.g. sunsets and sunny sandy beaches)	Household items (e.g. towel and mug) Office furniture (e.g. filing cabinets) Landscapes (e.g. crane and cityscape, shipyard) Animals (e.g. cow, bird) Transport (e.g. truck, bus) Abstract Art (e.g. brown cube) Builidings (e.g. concrete)
Experiment 2 Additional categories	Dangerous animals (e.g. sharks, snakes)		Plants (e.g.household and garden)

Experiments 3 & 4	Negative	Neutral
Additional categories	Animal cruelty (e.g. emaciated animals) Unpleasant animals (e.g. spiders)	None
Expanded categories	Aggression (e.g bombs and war victims)	Household items (e.g. whisk, kettle and plug)
Experiment 5 Expanded categories	Death and disease (e.g skin cancers, leprosy, smallpox and skin infections) Accidents (e.g. housefires)	Household items (e.g. glasses, cutlery and bath) Clothing (e.g. socks, slippers) Building materials (e.g. bricks, sand and rope) Gardens and garden furniture (e.g. wooden fence and bench) Food (e.g. beans and rice) Plants (e.g. algae) Miscellaneous (e.g. street map, bicycle pedal, paintbrush and boxes) Landscapes (e.g. mud roads, woods and traintracks)

Appendix 3

Selected pictures from the

Internaltional Affective

Picture System (IAPS)

Experiment 1:

Negative and Neutral Pictures

Negative		
IAPS Number	Description	% Agreement negative (British survey)
2800	Sad child	97%
3015	Accident	100%
6415	Dead tiger	97%
3170	Baby and tumour	100%
6550	Attack	100%
3120	Dead body	100%
2205	Couple in hospital	100%
9320	Vomit	100%
3064	Mutilation	100%
9040	Starving child	!00%
7359	Pie and bug	100%
6313	Attack (knife)	97%
9584	Dentist	97%
2095	Toddler and flies	100%
3053	Burn victim	100%
9301	Dirty toilet	100%
3168	Mutilation	100%
3063	Mutilation	100%
9252	Dead body	100%
3080	mutilation	100%
Mean Valence Rating: 3.84		

Neutral		
IAPS Number	Description	% Agreement neutral (British survey)
7035	Mug	90%
7020	Fan	90%
7010	Basket	97%
7002	Spoon	90%
7025	Stool	97%
7950	Tissues	87%
7235	Chair	87%
7190	Clock	87%
7187	Abstract art	87%
7179	Rug	87%
7036	Shipyard	90%
7050	Hair dryer	93%
7100	Fire hydrant	90%
7140	Bus	97%
7161	Pole	97%
7185	Abstract art	90%
7224	Filing cabinet	90%
7595	Traffic	90%
7705	Cabinet	96%
7080	Fork	87%
Mean Valence Rating: 3.51		

Experiment 2:

Negative Pictures

Negative	
IAPS Number	Description
2800	Sad child
3063	Mutilation
1300	Pitbull
6510	Attack
9180	Dead cows
3266	Injury
1050	Snake
9320	Vomit
3150	Mutilation
1114	Snake
6540	Attack
9040	Starving child
6415	Dead tiger
9301	Dirty toilet
3053	Burn victim
3064	Mutilation
3080	Mutilation
3261	Tumour
3140	Dead body
2053	Baby

Negative	
IAPS Number	Description
9220	Cemetery
3170	Baby and Tumour
1120	Snake
9584	Dentist
2095	Toddler and Flies
2205	Couple in Hospital
3168	Mutilation
3500	Attack
7359	Pie and bug
6550	Attack
6350	Attack
3400	Severed Hand
3102	Burn Victim
9252	Dead body
3110	Burn victim
3015	Accident
6212	Soldier
1525	Attack dog
Mean Valence Rating: 3.55	

Experiment 2:

Neutral Pictures

Neutral	
IAPS Number	Description
7179	Rug
7235	Chair
5533	Mushrooms
7186	Abstract art
2191	Farmer
7161	Pole
7190	Clock
7705	Cabinet
7595	Traffic
7160	Fabric
7031	Shoes
7950	Tissues
7010	Basket
7175	Lamp
7036	Shipyard
7090	Book
7035	Mug
7025	Stool
7187	Abstract Art
7034	Hammer

Neutral	
IAPS Number	Description
7140	Bus
7030	Iron
7096	Car
7004	Spoon
7000	Rolling pin
7060	Trashcan
7211	Clock
7006	Bowl
7020	Fan
7491	Building
7002	Towel
7080	Fork
7050	Hair-dryer
7224	Filing cabinets
7504	Stars
7100	Fire hydrant
7217	Clothes rack
7009	Mug
7185	Abstract art
Mean Valence Rating: 3.52	

Experiments 3, 4 and 5:

Negative Pictures

Negative	
IAPS Number	Description
1030	Snake
9921	Fire
9405	Sliced hand
9300	Dirty toilet
3266	Injury
9911	Car accident
1650	Jaguar
9400	Soldier
3261	Tumour
6530	Attack
1019	Snake
9570	Dog
3063	Mutilation
6260	Aimed gun
3130	Mutilation
3530	Attack
3140	Dead body
1931	Shark
9040	Starving child
6313	Attack
3053	Burn victim
1726	Tiger
3168	Mutilation
6230	Aimed gun
6834	Police
6312	Abduction
6212	Soldier
6571	Car theft
6350	Attack
9630	Bomb
7359	Pie and bug
3100	Burn victim

Neutral	
IAPS Number	Description
5130	Rocks
7004	Spoon
7030	Iron
7038	Shoes
7080	Fork
7161	Pole
7175	Lamp
7235	Chair
7037	Trains
7205	Scarves
7950	Tissues
2840	Chess
2980	Food basket
5530	Mushroom
5750	Nature
7031	Shoes
2215	Neutral man
7184	Abstract art
7285	Tomatoes
7710	Bed
5500	Mushroom
5720	Farmland
5020	Flower
2200	Neutral face
7190	Clock
7237	Abstract art
7590	Traffic
8311	Golfer
7010	Basket

Experiments 3, 4 and 5:

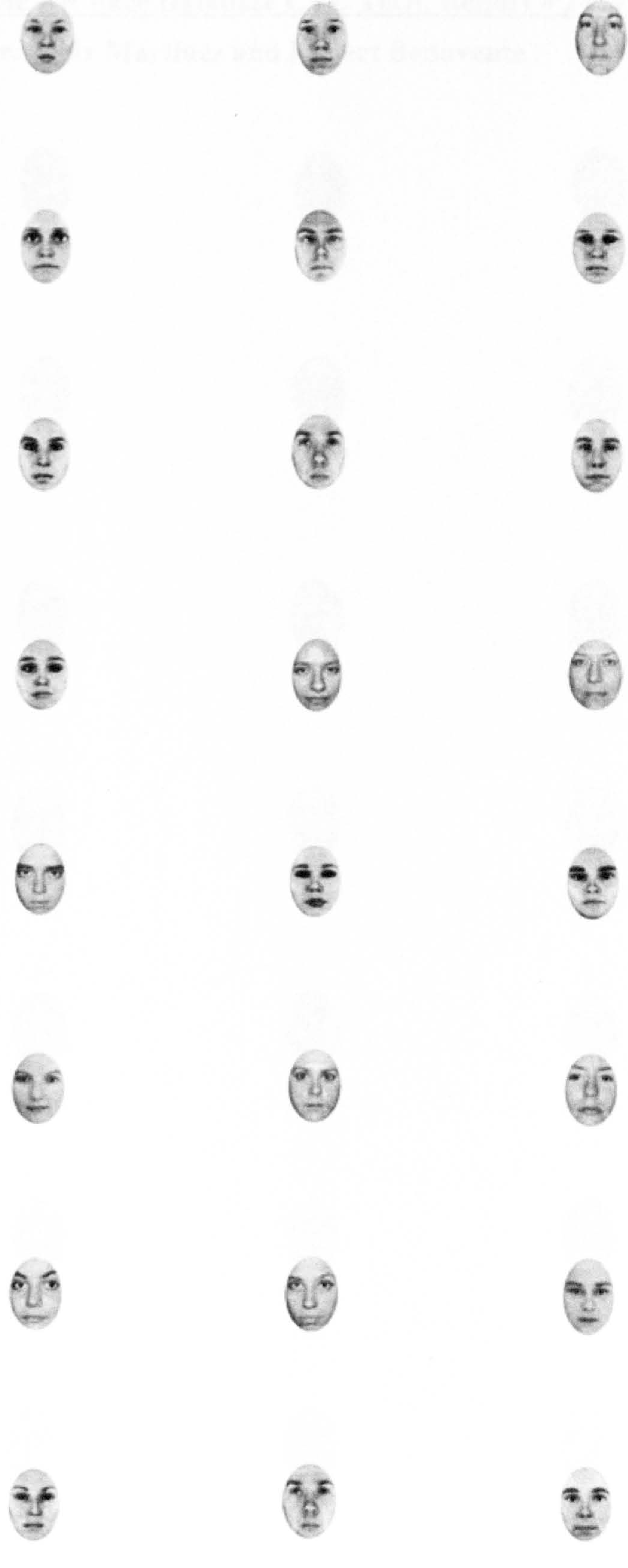
Neutral Pictures

Neutral	
IAPS Number	Description
5120	Pine needles
7002	Towel
7025	Stool
7036	Shipyard
7060	Trashcan
7160	Fabric
7187	Abstract art
7234	Ironing board
7000	Rolling pin
7180	Neon building
7900	Violin
2745.1	Shopping
2890	Twins
5520	Mushroom
9700	Trash
5870	Clouds
2210	Neutral face
7207	Beads
7283	Fruit
7595	Traffic
5800	Leaves
7009	Mug
7034	Hammer
7041	Baskets
7140	Bus
7179	Rug
7233	Plate
7700	Office
7090	Book
7500	Building
9360	Empty pool
2870	Teenager
7020	Fan
7035	Mug
7050	Hair-dryer

Appendix 4: Face Databases
(randomised selections: cropped)

Jha Laboratories

Assistant Professor Amishi Jha, University of Pennsylvania.



<u>The AR Face Database CVC Tech. Report # 24, 1998</u>

Dr. Aleix Martinez and Robert Benavente

The Face and Gesture Recognition Network

Aging Database: Andreas Lanikis, Cyprus College

AT and T. Laboratories, Cambridge

Formerly ORL Database of Faces

The Valid Database,

University College, Dublin

The Yale Face Database A and B

The Yale Face Database A and B

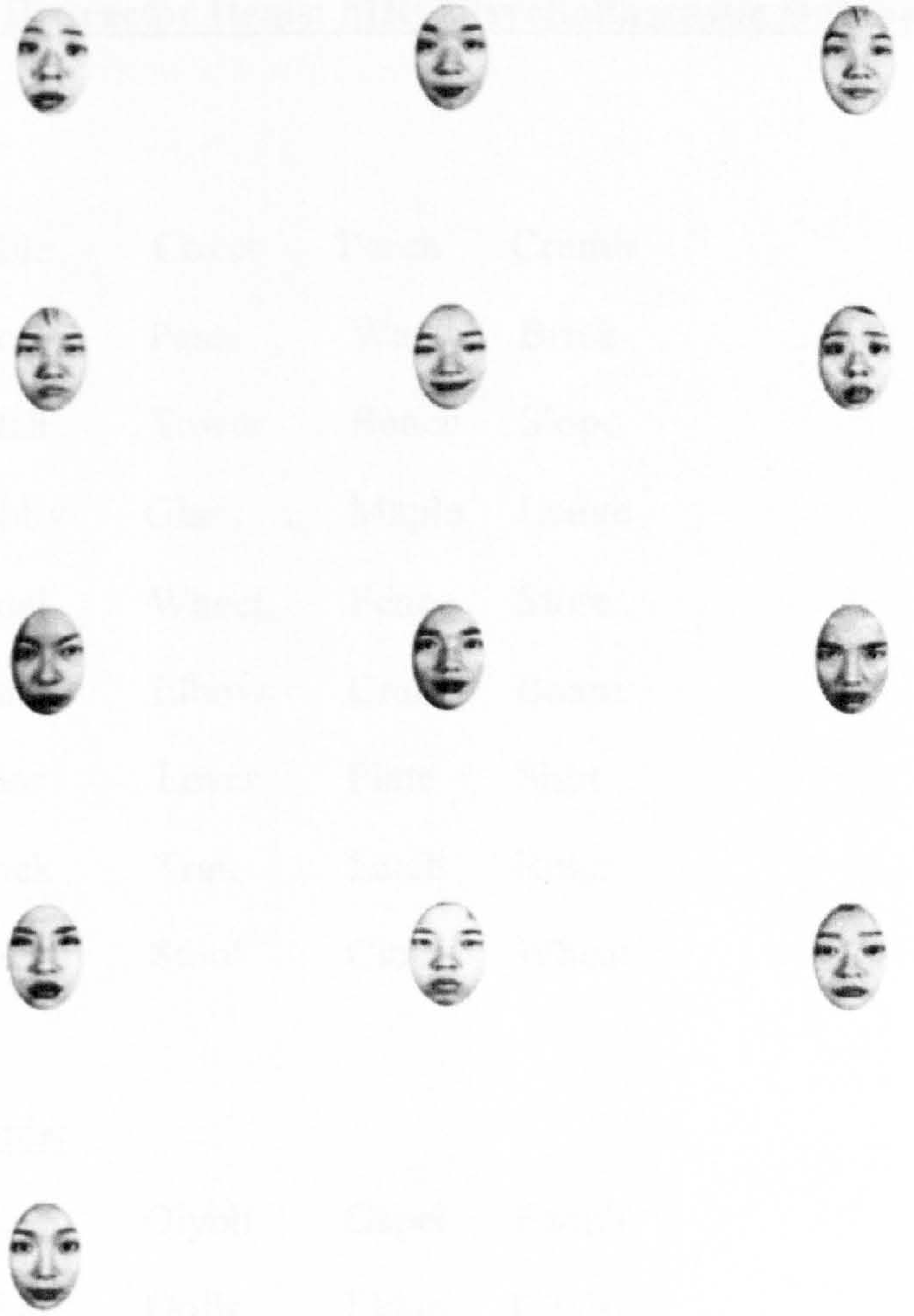
The Essex Face Database

The IMM Face Database

Informatics and Mathematical Modelling

<u>The UMIST Face Database, Manchester</u>

The Japanese Face Database (JAFFE)



Appendix 5

Lexical Distractor Items: MRC Psycholinguistic Database (2006)

Words:

Table	Cover	Porch	Crumb
Glove	Paste	Watch	Brick
Patch	Tower	Bench	Slope
Lobby	Glass	Maple	Lodge
Pedal	Wheel	Fence	Store
Stand	Elbow	Crane	Board
Floor	Lever	Plate	Shirt
Clock	Trail	Latch	Ruler
Track	Stool	Cloth	Wheat

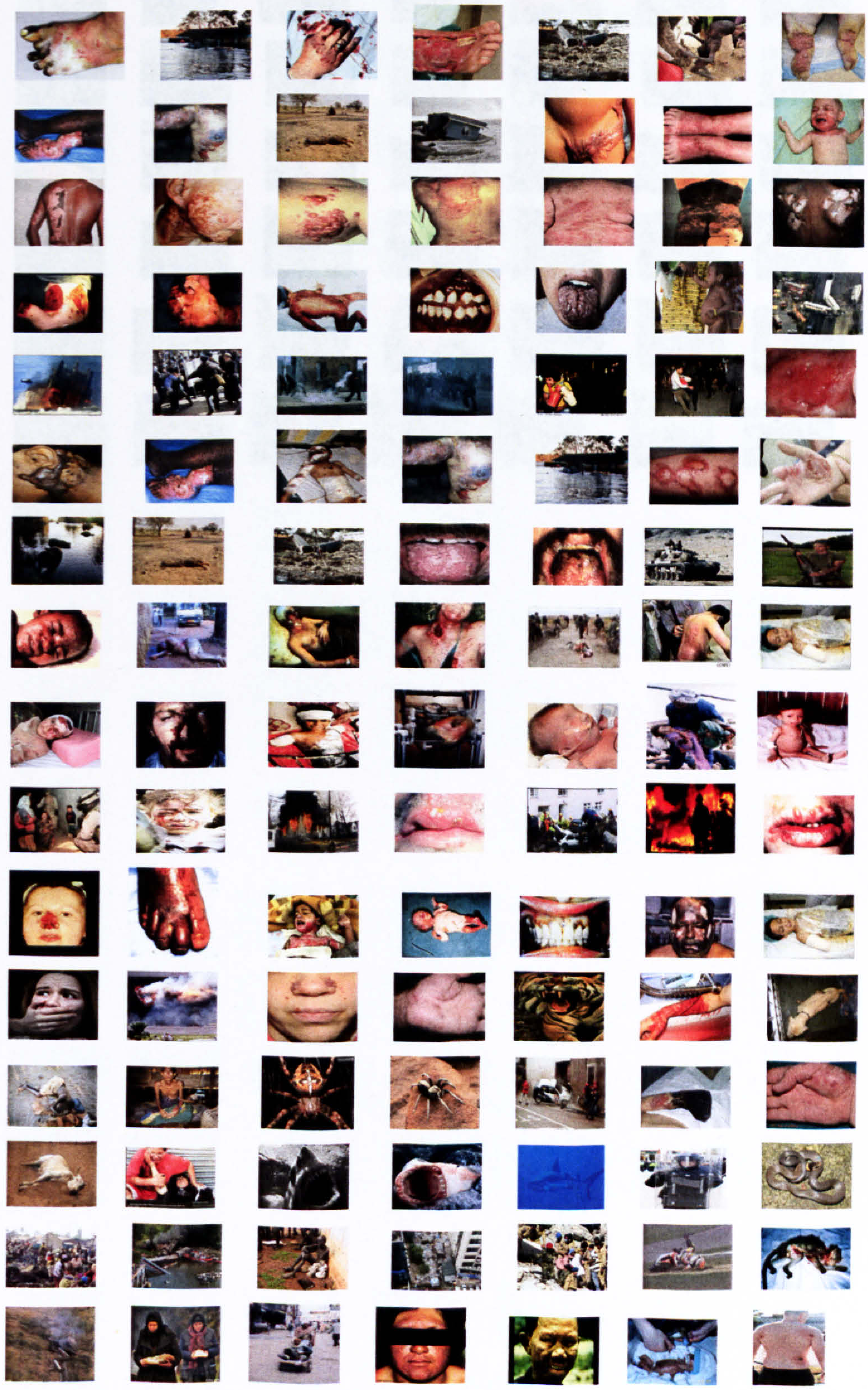
Non-Words:

Velog	Olybb	Ospel	Ewath
Eldap	Ooflr	Eldap	Ccolk
Elbat	Karct	Thapc	Brumc
Dastn			

Appendix 6

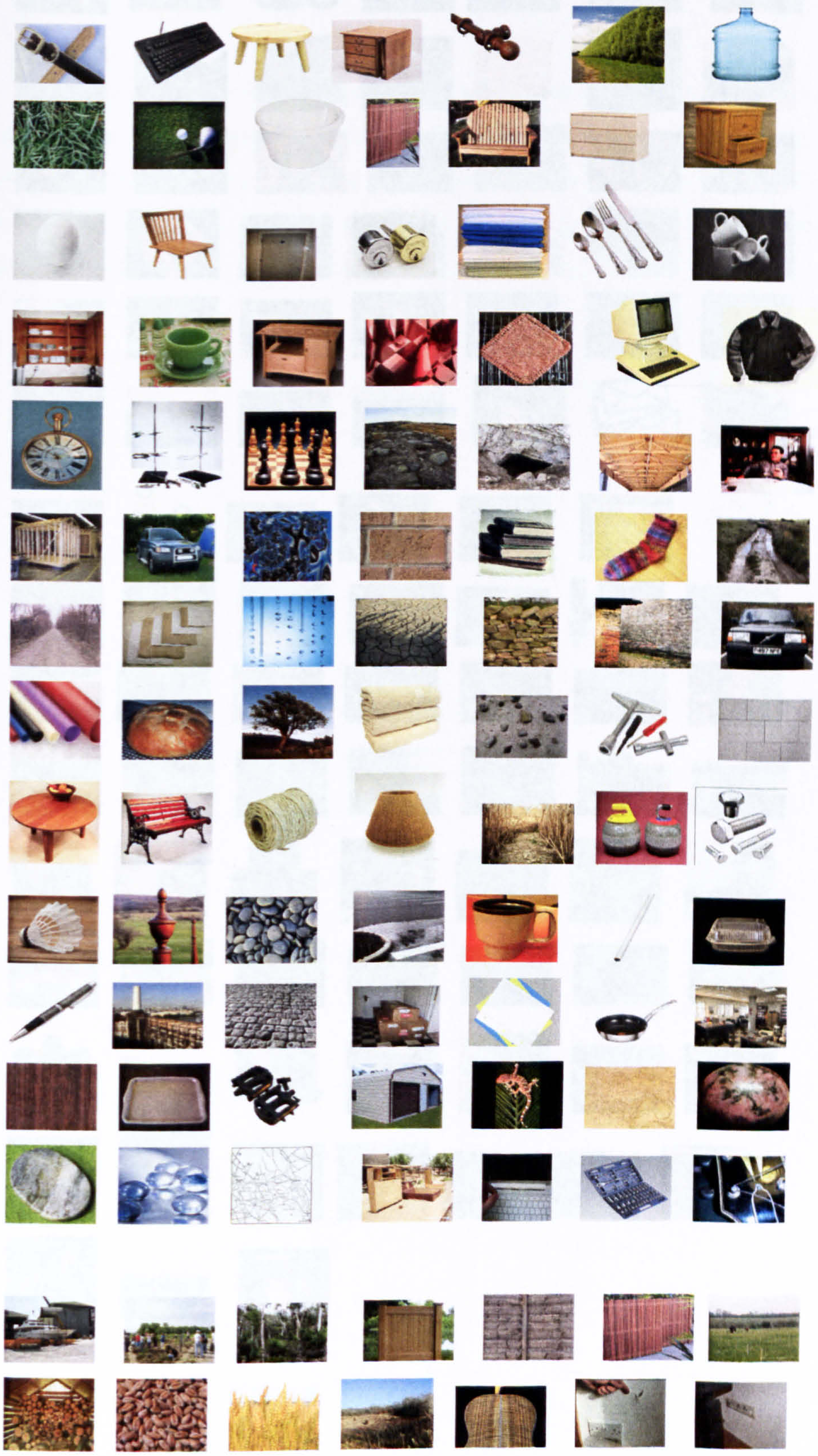
Extra Negative Google Images

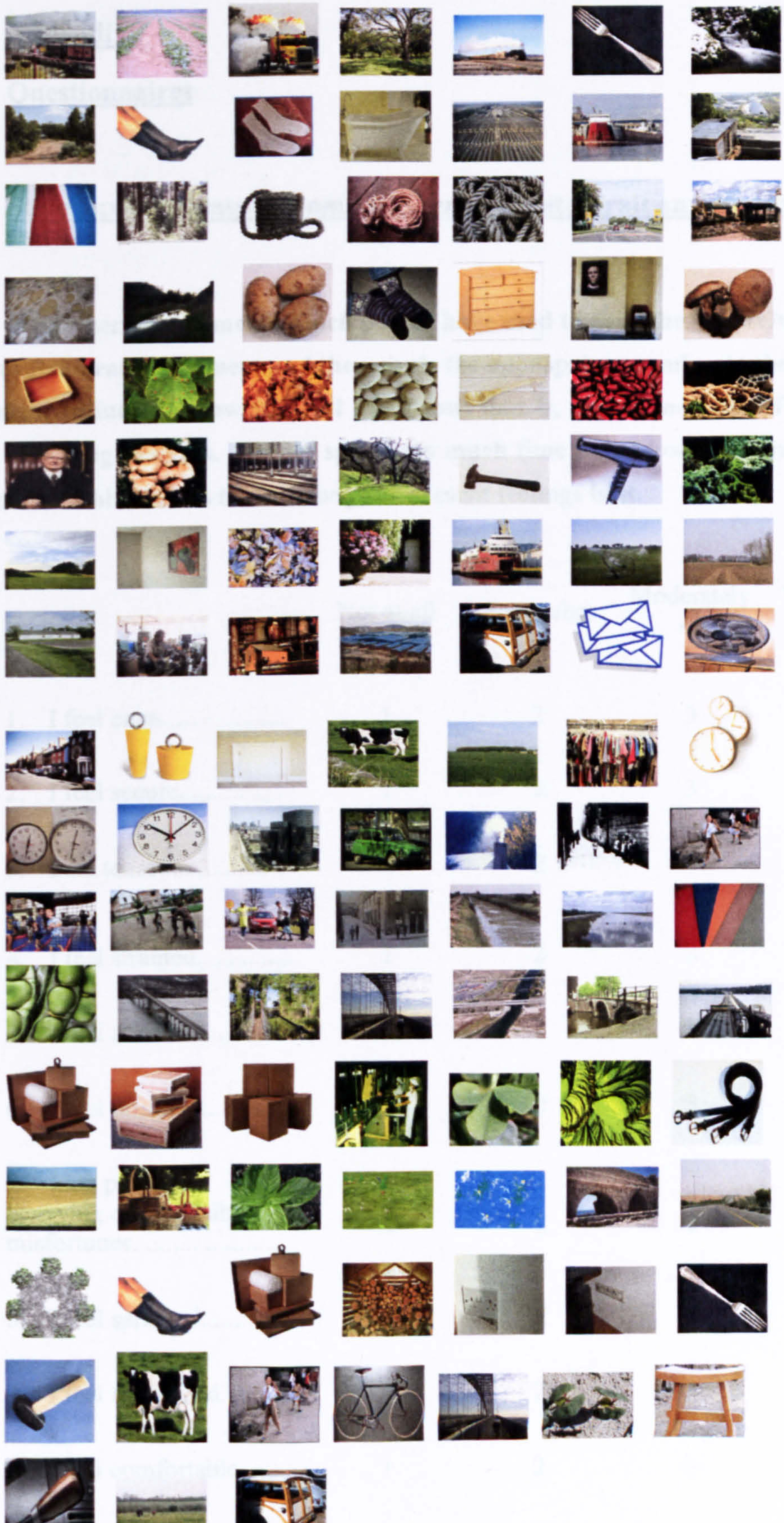
(random selection)



Extra Google Neutral Images

(random selection)





Appendix 7

Questionnaires

State anxiety measure from Spielbergers State Trait anxiety Inventory

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, at this *moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not at all	Somewhat	Moderately so	Very much so
1. I feel calm....................	1	2	3	4
2. I feel secure................	1	2	3	4
3. I am tense...................	1	2	3	4
4. I feel strained..............	1	2	3	4
5. I feel at ease.................	1	2	3	4
6. I feel upset....................	1	2	3	4
7. I am presently worrying over possible misfortunes.......................	1	2	3	4
8. I feel satisfied..............	1	2	3	4
9. I feel frightened...........	1	2	3	4
10. I feel comfortable........	1	2	3	4
11. I feel self-confident......	1	2	3	4
12. I feel nervous..............	1	2	3	4

13. I am jittery...................	1	2	3	4
14. I feel indecisive...........	1	2	3	4
15. I am relaxed.............	1	2	3	4
16. I feel content...............	1	2	3	4
17. I am worried................	1	2	3	4
18. I feel confused............	1	2	3	4
19. I feel steady..................	1	2	3	4
20. I feel pleasant...............	1	2	3	4

Trait anxiety measure from Spielbergers State Trait anxiety Inventory

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	Almost never	Some-times	Often	Almost always
1. I feel pleasant....................................	1	2	3	4
2. I feel nervous and restless....................	1	2	3	4
3. I feel satisfied with myself.................	1	2	3	4
4. I wish I could be as happy as others seem to be................................	1	2	3	4
5. I feel like a failure..........................	1	2	3	4
6. I feel rested................................	1	2	3	4
7. I am "calm, cool, and collected".........	1	2	3	4
8. I feel that difficulties are piling up so that I can not overcome them...................	1	2	3	4
9. I worry too much over something that really doesn't matter..........................	1	2	3	4
10. I am happy.......................................	1	2	3	4
11. I have disturbing thoughts..................	1	2	3	4
12. I lack self-confidence.......................	1	2	3	4
13. I feel secure....................................	1	2	3	4

14. I make decisions easily........................	1	2	3	4
15. I feel inadequate.........................	1	2	3	4
16. I am content.......................................	1	2	3	4
17. Some unimportant thought runs through my mind and bothers me..	1	2	3	4
18. I take disappointments so keenly that I can't put them out of my mind................	1	2	3	4
19. I am a steady person..................	1	2	3	4
20. I get in a state of tension or turmoil as I think over my recent concerns and interests................	1	2	3	4

The Centre for Epidemiological Studies Depression Scale (Ces D) Questionnaire

Below is a list of the ways you may sometimes feel or behave. Please indicate (bold, highlight, *) how often you have felt this way *during the past week.*

During the past week...	Rarely or none of the time **(i.e.less than 1 day)**	Some or a little of the time **(i.e.1-2 days)**	Occasionally or a moderate amount of time **(i.e. 3-4 days)**	Most or All of the time **(i.e.5-7 days)**
1. I was bothered by things that usually don't bother me..................	0	1	2	3
2. I did not feel like eating; my appetite was poor..........................	0	1	2	3
3. I felt that I could not shake off the blues even with help from my family............................	0	1	2	3
4. I felt that I was just as good as other people.................	0	1	2	3
5. I had trouble keeping my mind on what I was doing............................	0	1	2	3
6. I felt depressed................	0	1	2	3
7. I felt that everything I did was an effort........	0	1	2	3
8. I felt hopeful about the future.........	0	1	2	3
9. I thought my life had been a failure............................	0	1	2	3
10. I felt fearful.............................	0	1	2	3

11. My sleep was restless......................	0	1	2	3
12. I was happy..............................	0	1	2	3
13. I talked less than usual....................	0	1	2	3
14. I felt lonely..............................	0	1	2	3
15. People were unfriendly...................	0	1	2	3
16. I enjoyed life..................................	0	1	2	3
17. I had crying spells,.........................	0	1	2	3
18. I felt sad..................................	0	1	2	3
19. I felt that people disliked me...........	0	1	2	3
20. I could not "get going"....................	0	1	2	3