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**Investigating Proximate  
Mechanisms and Ultimate  
Functions of Memory for  
Emotional Events**

**Submitted for the degree of PhD**

**Date of submission: January 2007**

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## **Acknowledgements**

I would like to thank Ronan O' Carroll for being an excellent supervisor and whose expert guidance, enthusiasm, and patience made it possible for me to complete this thesis. I would like to thank Lindsay Wilson, my second supervisor, who also offered me valuable assistance. I also thank Nigel North for assisting me with my research with patients from Salisbury District Hospital, and Mr Allan and Irene Clark for facilitating me with my research with patients from Glasgow Southern General Hospital. I also thank Martin Sharp and Emad Al-Dujaili for their help with cortisol analysis.

I would also like to thank the technical staff in the Psychology department at Stirling University, including Steven Stewart, Bob Lavery, Catriona Bruce and Bruce Sutherland, and all the administrative staff including Kay Faichney and Kerry Fairbairns, Hazel Telfer, Anna Fenge, Hazel O'Donnell and Nicola Hunt.

Finally, special thanks to Miriam, for her continuous love and support and for always being there when I needed her.

## Abstract

This thesis is an investigation of the proximate mechanisms and ultimate functions of memory for emotional events. The theoretical basis of this Thesis is that in order to reach a full understanding of a biological phenomenon, it is important that both proximate and ultimate (functional) explanations for that phenomenon are explored. Chapters 2 and 3 present an examination of the proximate mechanisms involved in memory consolidation of emotional events. In Chapter 2, three experiments are presented each testing the hypothesis that stress hormone activation immediately following viewing an emotional event enhances memory for that event. Each of the three experiments failed to find an enhancing effect of stress hormone activation on memory consolidation. Chapter 3 describes an investigation into whether the reduced feedback from the body to the brain, which occurs as a result of total spinal cord transection, diminishes the intensity of emotional experience and therefore impairs memory for emotional events. The results of this investigation revealed no differences between spinal cord transection patients and matched control participants in emotional expressivity, emotional awareness and in memory for emotional material. Chapters 4 and 5 explore how memory and emotion may interact differently for males and females and in manner that facilitates their survival and reproduction. Evolutionary theory argues that males should be more concerned than females about threats to their social status, whereas females should be more concerned about threats to their physical appearance and sexual reputation. Chapter 4 describes two experiments testing whether a) males have enhanced emotional arousal and memory for words implying they are of low social status; b) females have enhanced emotional arousal and memory for words implying they are physically unattractive and sexually untrustworthy. The results of these experiments showed that females had enhanced memory for words relating to physical appearance, and partial evidence that males have

enhanced memory for words relating to social status. Chapter 5 tests the evolutionary theory that males should be more emotionally aroused and thus have greater memory for cues relating to sexual infidelity (the thought of their partner having sex with another man), whereas females should be more emotionally aroused and have greater memory for cues to emotional infidelity (the thought of their partner forming a close emotional attachment with another woman). It also examines whether relationship status affects emotional arousal and memory for these cues. The results did not find any support for these hypothesised sex difference in memory. However, those 'currently in a relationship' did show enhanced emotional arousal to cues to sexual infidelity compared to those 'currently not in a relationship'. Chapter 6 presents an investigation concerning the evolutionary hypothesis that individuals tend to have enhanced recognition memory for the faces of deceivers or 'liars'. This chapter describes a study in which participants viewed a series of short video clips of individuals, half of whom were lying, half telling the truth. Participants' memory for the individuals that appeared in the video clips was tested but there was no evidence of enhanced memory for the faces of 'liars'. Chapter 7 provides a general discussion of the findings of this thesis. The failure to find an enhancing effect of post learning stress hormone activation on memory for emotional material, and the failure to find an impairment in memory for emotional material in people with total spinal cord transection contradict two established views on the proximate mechanisms involved in emotion, and emotions effect of the brain. How these findings relate to the established mainstream views on emotion and memory are discussed. The findings of studies concerning the functional interaction of memory and emotion presented in this thesis are also discussed in relation to previous research.

## **Proximate mechanisms and ultimate functions of memory for emotional events**

### **Chapter 1 General Introduction**

The fundamental rationale of this thesis is that in order to fully understand how and why memory and emotion interact, it is important to investigate both the proximate mechanisms and ultimate functions of memory for emotional events. This chapter will review both proximate mechanisms and ultimate functions of memory for emotional events, and will begin by discussing the evidence that indicates that emotional events tend to be remembered in more detail and generally with greater accuracy than neutral events. The mechanisms of emotional arousal, memory consolidation and memory consolidation of emotional events will then be discussed. Particular attention will be paid to the role of stress hormones in the memory consolidation of emotional events. The importance of feedback from the body to the brain for emotional arousal and for memory consolidation of emotional events will also be addressed.

It is becoming increasingly important in psychology to not only explain a biological (or behavioural) phenomenon in terms of its proximate mechanisms and its immediate antecedent triggers or causes, but to also elucidate its functional or adaptive significance. Why is a certain trait or behavioural mechanism present, and what adaptive function does it serve? The second half of this chapter will hypothesise how one might expect memory and emotion to interact in an adaptive fashion, in a manner congruent with the selective pressures humans have faced in our ancestral past. Some of the differing selective pressures males and females have faced will be reviewed and based on these selective pressures; predictions will be formed as to how memory and emotion should interact to solve these evolutionary 'problems'.

## **1.1 Memory for emotional events**

### *1.1.1 The evidence*

Emotional events tend to be remembered with more vividness and detail than events that do not invoke emotional arousal. For example, Reisberg, Heuer, McLean & O'Shaughnessy (1988) found that participants' emotionality ratings for past events were positively correlated with ratings of how vivid those events were. This effect was found irrespective of what type of emotion the past event invoked; whether it was sadness, anger, fear or joy. This relationship between vividness and emotionality held true for both personal and public events. Wolters & Goudsmit (2005) tested participants' memory of the September 11<sup>th</sup> attacks, at 2 weeks and 2 months after the attacks took place. Participants reported very vivid memories of the event and also had a high confidence that their memories of the event were accurate. Additionally, Walker, Vogl & Thompson (1997) found that participants' ratings of emotional events (both pleasant and unpleasant) were a good indicator of whether they thought they could or could not remember the event. Other authors have also shown that strength of emotion positively correlates with memory vividness for autobiographical memories of both a traumatic and a positive nature (Pillemer, Goldsmith, Panter & White 1988; Rubin & Kozin 1984; Porter & Birt 2001). In research looking at memory consolidation of emotional events, over a longer time period, Kraft (2004) showed how after fifty years, World War II holocaust survivors still had remarkably clear, vivid and powerful memories of their experiences.

Research therefore strongly indicates that memories of emotional events are remembered particularly vividly, however, this does not necessarily mean emotional events are remembered with greater accuracy than events of an emotionally neutral nature. A



considerable amount of research on the field of 'flashbulb' memories suggests that it cannot be taken for granted that remembering an emotionally arousing event vividly and in great detail means that those details are in fact entirely accurate. The term 'flashbulb memories' refers to the remarkable clear, detailed and vivid memories people have of emotional events in their lives of a very important nature, and was first coined by Brown & Kulik (1977). These authors used the term to describe people's remarkably vivid memories regarding the assassination of John F Kennedy (Brown & Kulik 1977). Vividness does not always translate into accuracy; Lotus & Burns (1982) found that participants had reduced memory for an emotional video presentation (involving a boy getting shot in the face) in comparison to a matched neutral version. An example of vividness translating into accuracy is provided by Yuille & Cutshall (1986), who interviewed thirteen individuals, four to five months following a real life violent crime (involving a shooting and death) they had witnessed. They found the descriptions these witnesses provided of the crime very accurately matched police and forensic evidence that had been compiled on the crime. Other authors have also found accuracy as well as great detail in recall of 'flashbulb memories' (e.g. Conway et al. 1994; McCloskey et al. 1988; Winningham et al. 2000; Neisser 1996; Philippot & Rime 1998; Kensinger, Krendl & Corkin 2006). Kensinger et al. (2006), for example, compared memory for the 2003 Superbowl with memory for the Columbia space shuttle disaster that occurred around the same time. Participants rated the shuttle disaster as being more emotionally arousing and showed more accurate recall of the disaster (in memory test 7 months later), suggesting that emotion does indeed accurately enhance memory of an event.

Laboratory studies have often focused on testing the 'Easterbrook hypothesis' (Easterbrook 1959): the idea that emotion enhances memory for an event's centre (Reisberg & Heuer 2004). Easterbrook (1959) proposed that an emotionally aroused animal would focus its

attention on the centre of threatening stimulus at the expense of the periphery. This hypothesis predicts that emotional arousal will enhance memory for details at an events centre and impair memory for details at an events periphery. In support of the 'Easterbrook hypothesis, Christianson & Loftus (1991) found enhanced memory for central and impaired memory for peripheral details of an emotional event compared to memory performance of a neutral event. However, other research has shown that emotional arousal enhanced memory for both central and peripheral details of an arousing event (Heuer & Reisberg 1990). However, as Reisberg & Heuer (2004) point out, these confusions in the literature may be the result of differing criteria used to classify details as central and peripheral. For example, Christianson & Loftus (1990) defined central details as details that were located spatially in a central location, and peripheral details were located spatially on the periphery or in the background. In contrast, Heuer & Reisberg (1990) defined central details as any details that could not be removed without altering the plot or narrative of the story; and peripheral details as ones that could be removed from the narrative without altering the fundamental plot of the story. Heuer & Reisberg (1992) used both these categorisations for central and peripheral details when examining the memory performance of participants for the 'Doctor/Mechanic' slide presentation. This Doctor/Mechanic presentation was first developed by Heuer (1987). It involves 2 slides presentations, both depicting a mother and her son leaving their house to go and visit their father at his work place. In the neutral version the father is a mechanic and the viewer sees the father repair a car engine; in the emotional version the father is a surgeon and the viewer sees the father perform an unpleasant surgical procedure. The authors found emotion enhanced memory for spatially central details and impaired memory for spatially peripheral details. They also found emotion enhanced memory for details relevant to the core plot of the story. Safer, Christianson, Autry & Osterlund (1998) showed participants a slide presentation of images depicting a story that was either emotionally neutral or

arousing in nature. In a subsequent memory test, participants remembered the emotionally arousing images in the slide presentation as being more 'zoomed in' than the emotionally neutral images. Two studies by Wessel & Merckelbach yielded similar results (1997; 1998). In their first study the authors showed individuals with a spider phobia, and control participants, a jar containing a live spider. A subsequent memory test revealed the phobic participants had enhanced memory for central details of the stimulus compared to controls. In a second study the authors showed spider phobic patients and controls pictures of spiders and again, a subsequent memory test revealed enhanced memory for spatially central details of the stimuli for phobic participants compared with controls. As Reisberg & Heuer (2004) surmise, the general consensus in the literature is that emotional arousal enhances memory for an events centre (both spatially and in terms of importance to storyline), but seems to impair memory for peripheral events (both spatial and in terms of relevance to storyline).

A similar idea to that of the Easterbrook hypothesis is the theme of investigation concerning 'weapons focus'. This is the idea that victims of a crime that involves a weapon tend to focus on the weapon rather than the other characteristics of the perpetrator of the crime, for example the perpetrator's face (e.g. Loftus, Loftus & Messo 1987; Stanny & Johnson 2000). A meta-analysis of laboratory weapon focus studies by Steblay (1992) indicates that the weapons focus effect is greater when stress is high and the context most resembles real life situations. However, more recent studies of real life crime indicate that victims of a crime have greater memory for the perpetrator when a weapon is involved (Tollestrup, Turtle & Yuille 1994; Cooper, Kennedy, Herve & Yuille 2002). For example, in a study concerning female victims of sexual assault (Cooper et al. 2002) found that those attacked with a weapon had greater memory for details of the crime than those assaulted without a weapon

Recent research looking at ‘thematically’ induced emotions (emotions induced via our relationships with other people) rather than visually induced emotions has failed to find any difference in recall between central and peripheral details. Laney, Heuer & Reisberget (2003) asked half their participants to view a slide presentation with an accompanying narrative describing an attempted date rape, while the other half viewed a visually identical presentation but with a narrative describing a man and a woman happily on a date. The slides themselves were unemotional; the arousal manipulation was contained only within the emotional narrative. The memory test revealed enhanced memory for the arousing narrative, with peripheral details also being remembered with greater accuracy in the arousing narrative. A second study by these authors employing a similar methodology revealed participants showed enhanced memory for both central and peripheral details of the arousing narrative. Reisberg & Heuer (2004) conclude on the basis of these findings that emotion *per se* does not lead to memory narrowing (i.e. enhanced memory for central details at the expense of peripheral details) but rather a ‘powerful attention grabbing magnet’ that commands attention, thus drawing attention away from other areas, is responsible for the memory narrowing effect.

## 1.2 *Why do we have enhanced memory for emotional events?*

### 1.2.1 *Levels of explanation*

Evolutionary theory and thus the concept of *function* has tended to be ignored by psychologists due to their use of Newtonian physics as the model for correct science (Zeiler 2002). This reliance on the Newtonian model began around the time that psychology developed from philosophy as an independent branch of science. This model

regards good science as one that looks to the immediate antecedent events that produce a particular behaviour or biological phenomenon (Zeiler 2002). However, thanks to the work of biologists such as Earnst Mayr and the ethologist Niko Tinbergen the importance of asking ‘what function’ a particular biological phenomenon serves has become more and more important in psychology.

The biologist Earnst Mayr was one of the first to elucidate the importance of separating ‘why’ explanations of biological phenomena into *proximate* and *ultimate* explanations. For Mayr (1961) proximate explanations involve the causal aspects of “structural elements, from molecules up to organs and whole individuals” (p.1502). Proximate explanations of why a biological phenomenon operates the way it does is really asking “How does something operate?” Mayr (1961) uses an example from animal behaviour to illustrate his point. If one asks why do warbler birds migrate, one should look at the warblers internal physiology or the external conditions that trigger the act of migration. “The warbler flew south because its migration is tied in with photoperiodicity. It responds to the decrease in day length and is ready to migrate as soon as the number of hours of daylight have dropped below a certain level” (p. 1503). The event that triggered the act of migration, Mayr (1961) calls the “extrinsic physiological cause: ‘the warbler migrated on the 25 of August because a cold air mass, with northerly winds, passed over our area on that day. The sudden drop in temperature and the associated weather conditions affected the bird, already in a general physiological readiness for migration, so that it actually took off on that particular day’” (p. 1503).

Functional explanations of why questions are really asking “how come?” according to Mayr (1961): “The warbler has acquired a genetic constitution in the course of the evolutionary history of its species which induces it to respond appropriately to the proper

stimuli from the environment. On the other hand, the screech owl, nesting right next to it, lacks this constitution and does not respond to these stimuli. As a result, it is sedentary” (p. 1502). Therefore ultimate (or functional) explanations are concerned with *how* certain traits have become prevalent in populations (Mayr 1961; 1993; Ariew 2003). They are concerned with what survival and reproductive advantages have these traits conferred to their bearer that has allowed the bearer of the trait(s) to increase in the population (thus increasing the prevalence of that trait(s) in the population). According to Mayr (1961), “ultimate causes are causes that have a history and that have been incorporated into the system through many thousands of generations of natural selection” (p. 1503). Other biological scientists take a similar view to Mayr. Ariew (2003) frames proximate explanations as dynamical as they refer to causal properties occurring during an organism’s lifetime, including physiological mechanisms. Ultimate explanations according to Ariew (2003) deal with questions relevant to the diversity of life, for example “Why are certain traits prevalent?” and “Why will certain traits continue to persist?”

The animal ethologist, Niko Tinbergen, outlined four ways of answering ‘why’ questions in animal behaviour which can be equally well applied to all areas of biological science (Tinbergen 1963). Tinbergen proposed that ‘why’ can be answered proximately, developmentally, ultimately and phylogenetically. He believed a complete explanation of any biological phenomenon required addressing the phenomenon using these four questions. A number of authors cite the example of a mother breastfeeding her child to illustrate how Tinbergen’s four whys can be applied to biological phenomena (e.g. Laland & Brown 2002; Barrett et al. 2002). In order to investigate the *proximate* mechanism responsible for the behaviour one would ask what hormonal processes, or extrinsic events (such as the baby crying) underlined the behaviour? To investigate *development* of this behaviour over time one, would ask how has the mother learned to look after her infant,

(e.g. was it by observing other females partaking in similar behaviour?), and what role have genes played in manifesting the behaviour (e.g. is there an innate genetic predisposition for a mother to want to care for her newly born infant?). *Functional* (or ultimate) causes could be investigated by asking what fitness advantage does breastfeeding confer on a mother and her infant that has made it favored by natural selection? To investigate *phylogenetic* causes of behaviour one would ask why is this particular behaviour prevalent amongst mammals and not other animal types? (Laland & Brown 2002; Barrett et al. 2002). Although, developmental and phylogenetic explanations are very important, this thesis will concentrate on proximate and ultimate explanations for memory for emotional events.

### *1.2.2 The importance of proximate and ultimate explanations*

So why is it so important to provide a proximate and ultimate explanation in order to fully understand a biological phenomenon? Sober and Wilson (1998) contend that "when a behavior evolves, a proximate mechanism also must evolve that allows the organism to produce the target behavior" (p.199). The authors also state "the behavior evolved in an ancestral lineage because it was favored by natural selection; within the lifetime of an organism, the behavior now occurs because there is an internal mechanism inside the organism that causes it" (Sober & Wilson 1998, p. 200). The discipline of Evolutionary Psychology argues that framing ultimate causes is an essential requirement for any hypothesizing about proximate causes (Downes 2005). Evolutionary psychologists contend that any proximate causal hypothesis is dubious in the absence of a sound supporting functional or ultimate explanation (Downes 2005).

*Why* do people show enhanced memory for emotional, compared to emotionally neutral events? This dissertation is interested in examining both proximate and ultimate explanations of memory for emotional events. This chapter will examine, firstly, the proximate mechanisms involved in a) emotional arousal, b) memory consolidation and c) memory consolidation for emotional events. Then the literature concerning ultimate explanations concerning memory for emotional events will be discussed.

### *1.3 Proximate mechanism involved in memory for emotional events*

#### *1.3.1 Defining emotion*

Three very influential neuroscientists LeDoux, Damasio and Panskepp all agree that emotions are mainly biological (particularly neurobiological), and are a result of natural selection (i.e. they emerged and persist due to the survival function they confer) (Lacroix 2001). Ledoux describes emotions as “biological functions of the nervous system” (1996, p.12) that “did not evolve as conscious feelings. They evolved as behavioural and physiological specialisations, bodily responses controlled by the brain, that allowed ancestral organisms to survive in hostile environments and procreate” (1996, p.40). Damasio emphasises the role the whole body plays in emotion: “I see the essence of emotions as the collection of changes in body state” (1994, p.139). He also states an “emotion is the combination of a mental evaluative process, simple or complex, with dispositional responses to that process, simple or complex, mostly toward the body proper, resulting in an emotional body state, but also toward the brain itself, resulting in additional mental changes” (1994, p.139). Damasio also proposes an ‘as if loop’ in the brain that allows emotions to be experienced without the involvement of the body, but believes these emotions are less strongly felt (Damasio 1994).



### Box 1. Damasio's definition of emotion

“

1. Emotions are complicated collections of chemical and neural responses, forming a pattern; all emotions have some kind of regulatory role to play, leading in one way or another to the creation of circumstances advantageous to the organism exhibiting the phenomena; emotions are about the life of an organism, its body to be precise, and their role is to assist the organism in maintaining life.
2. Notwithstanding that learning and culture alter the expression of emotions and give emotions new meanings emotions are biologically determined processes, depending on innately set brain devices, laid down by a long evolutionary history.
3. The devices which produce emotions occupy a fairly restricted ensemble of subcortical regions, beginning at the level of the brain stem and moving up to the higher brain; the devices are a set of structures that both regulate and represent body states.
4. All the devices can be engaged automatically, without conscious deliberation. Considerable individual and cultural variation in what induces an emotional reaction does not deny the fundamental stereotypicity, automaticity, and regulatory purpose of the emotions.
5. All emotions use the body as their theatre (internal milieu, visceral, vestibular and musculoskeletal systems) but emotions also affect the mode of operation of numerous brain circuits: the variety of the emotional responses is responsible for profound changes in both the body landscape and the brain landscape. The collection of these changes constitutes the substrate for the neural patterns which eventually become feelings of emotions.

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Damasio (1999, p.51-52)

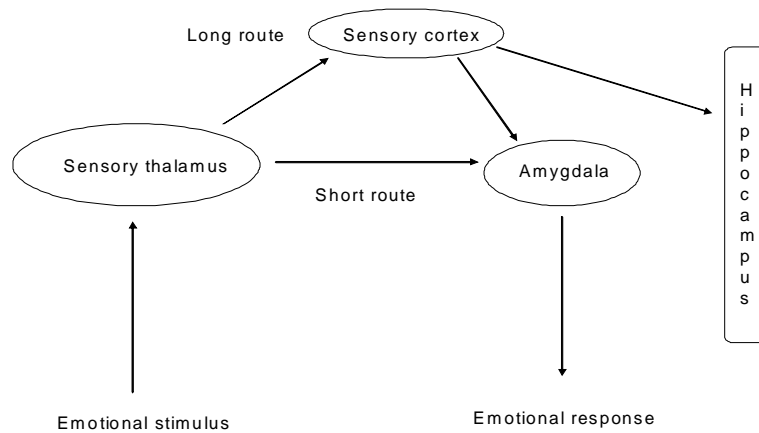
### *1.3.2 The mechanics of emotion*

It is now known that different brain systems are responsible for producing different emotions (LeDoux 1998; Damasio 1999). Most of the areas of the brain responsible for producing emotion are contained in the subcortical region of the brain (i.e. below the cerebral cortex) (Damasio 1999); some of these sites that are important in producing emotions include the amygdala, hypothalamus, the periaqueductal gray (PAG) (LeDoux 1998; Damasio 1999). The amygdala is a small region in the forebrain and was named by the early anatomists for its resemblance in shape to an almond (LeDoux 1998).

Information from a threatening stimulus is relayed to the amygdala, which in turn activates, via neural projections, autonomic, hormonal and behavioural response systems located in the brainstem (LeDoux 2000). Sensory information can travel direct from the thalamus to the amygdala, thus by passing cortical areas (see Figure 1.1). A region in the amygdala called the central nucleus (CE) connects to the areas in the brain stem that control heart rate and other autonomic responses (LeDoux 1998). In response to a threatening stimulus the CE plays a pivotal role in inducing behavioural, autonomic and hormonal responses. Neuronal projections from the CE to the central gray induce freezing; projections to the lateral hypothalamus are responsible for changes in blood pressure; projections to the paraventricular nucleus are responsible for the release of stress hormones; and projections to the reticulopontis caudalis induce the startle reflex (LeDoux 1998).

Emotional responses, therefore, can occur without necessarily requiring input from the more advanced information processing systems found in the neocortex (LeDoux 1998; LeDoux 2000). However, this “low road” as LeDoux calls it may only be useful for certain types of threatening stimuli. A study illustrating this was performed by Jarrell, Gentile, Romanski, McCabe & Schneiderman (1987) who presented two similar tones to rabbits, one of which was paired with a foot shock and the other not. The rabbits were capable of distinguishing between the differing tones and only elicited a fear response for the tone paired with the shock. However, when the auditory cortex was lesioned the rabbits were no longer capable of distinguishing between the two tones and now elicited a fear response for both tones. Neurons from the thalamus to the lateral nucleus of the amygdala are said to be ‘broadly tuned’ and react to a broad range of stimuli, whereas neurons projecting from the thalamus to the auditory cortex are ‘narrowly tuned’ and are more specific about what stimuli they react to (Weinberger 1995).

The direct thalamic path to the amygdala has the advantage over the more indirect cortical input pathway of being a quicker route for information to travel, thus allowing for a faster reaction to stimuli. It takes 12 milliseconds for a signal to travel the thalamic pathway versus approximately 23 milliseconds via the cortical pathway (LeDoux 1998). Both of these pathways (the thalamo-amygdala and cortico-amygdala) merge in a region of the amygdala called the lateral nucleus.



**Fig 1.1 The direct thalamo-amygdala route is shorter but does not benefit from cortical processing and can therefore only provide basic information to the amygdala. This route can be useful in dangerous situations when a quick response is needed.**

Adapted from LeDoux (1998, p.164)

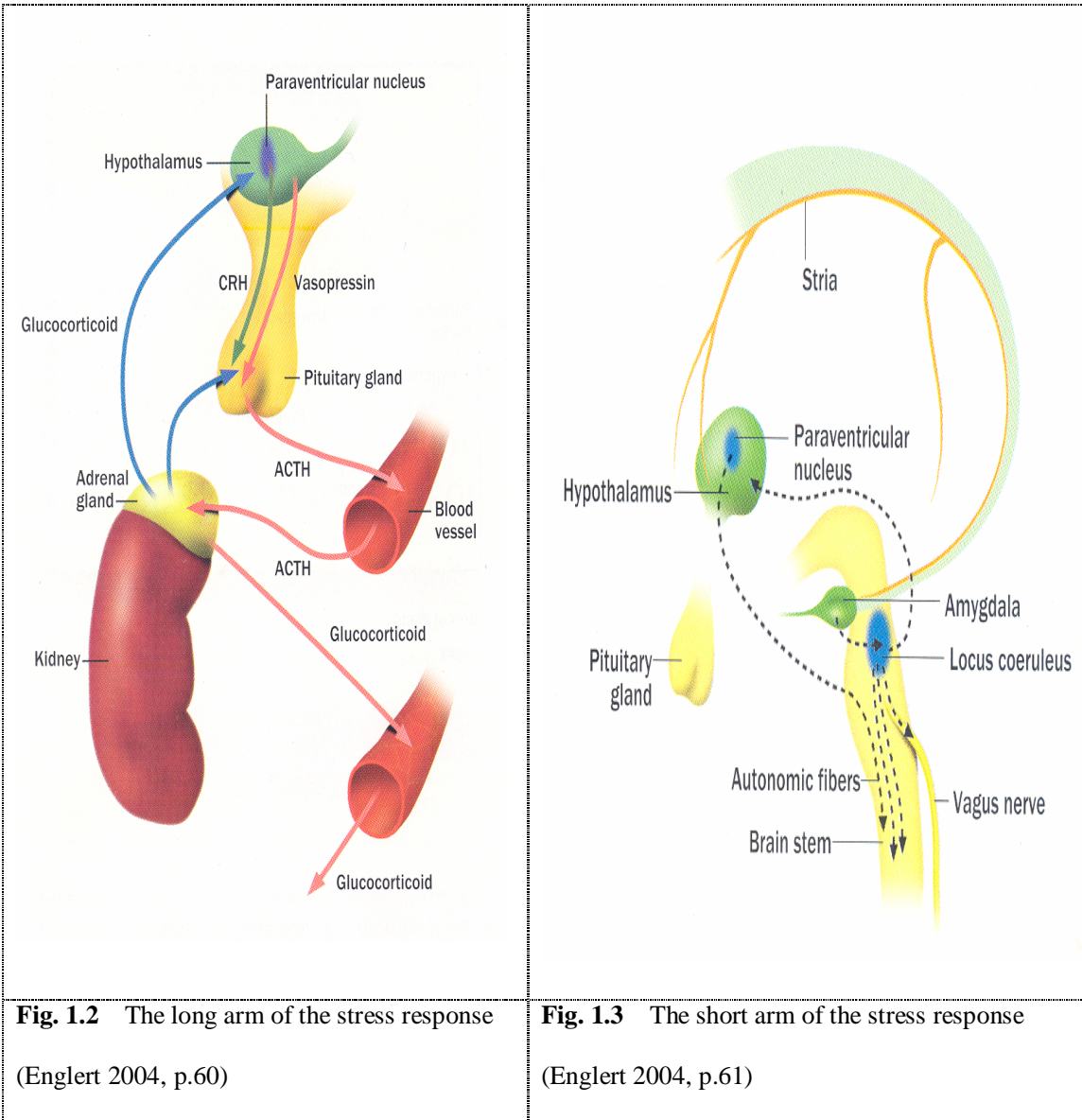
### *1.3.3 Emotional arousal and the stress hormone response*

The stress response is a coordinated pattern of changes that is useful in situations in which the organism is faced with possible damage or a loss of resources. In the face of a threat, the central nucleus of the amygdala alerts the paraventricular nucleus (PVN) in the hypothalamus. The PVN secretes corticotrophin releasing hormone (CRH) which travels to the pituitary gland and triggers the release of adrenocorticotrophic hormone (ACTH) into the blood stream. ACTH, travelling via the blood stream activates the production of glucocorticoid hormones in the adrenal glands of the kidneys, these hormones are then released into the blood stream. Glucocorticoid hormones increase the level of glucose in the blood, thus increasing the provision of energy for muscles and nerves. The circulating glucocorticoids also play a role in attenuating the stress hormone response by bathing the hypothalamus which causes CRH secretion to be suppressed. This system of stress hormone activation is known as the 'long arm' of the stress response (see Figure 1.2) (Feldman & Conforti 1985; Sapolsky & Meaney 1986; Jacobson & Sapolsky 1991; Englert 2004).

CRH is also involved in the 'short-arm' of the stress response. Again the amygdala sends information from a threatening situation to the paraventricular nucleus, triggering the release of CRH, which travels to the pituitary gland and activates to fire nerve impulses via nerves, including the vagus nerve. Noradrenergic activity in the locus coeruleus also increases and it directly signals the hypothalamus, which in turn signals the autonomic nerve fibres in the brain stem. The locus coeruleus also directly activates stress responses in glands and organs throughout the body via autonomic nerve fibres, including the release of adrenaline from the medulla of the adrenal gland in the kidney (see Figure 1.3)

(Feldman & Conforti 1985; Sapolsky & Meaney 1986; Jacobson & Sapolsky 1991; Englert 2004).

As we will see later, the release of stress hormones during an emotionally arousing situation has a critical role to play in memory consolidation processes for that emotional situation.



#### 1.3.4 *The process of memory consolidation*

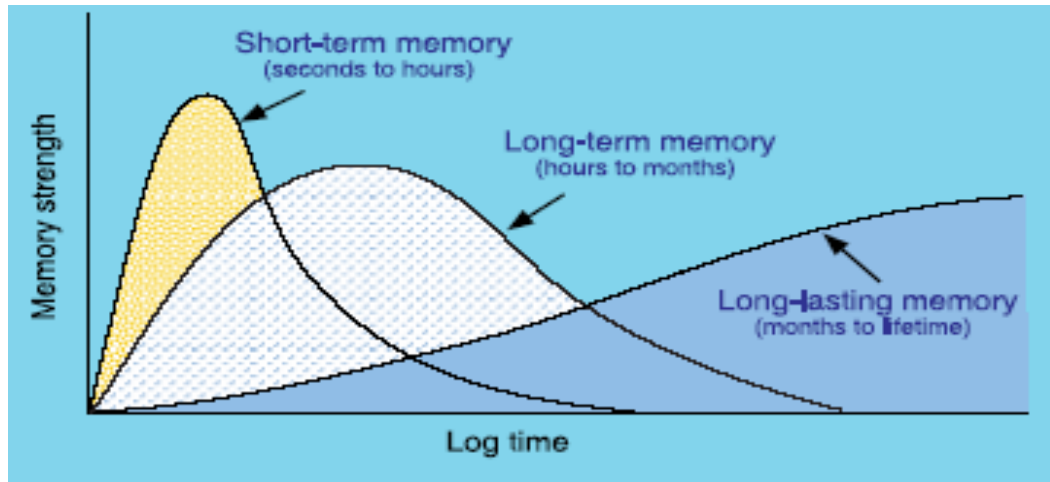
Muller & Pilzecker (1900) helped to establish the *consolidation* hypothesis of memory formation. This hypothesis contends that memories start their existence in a fragile state and consolidate slowly over time. These authors showed how participants' memory for newly learned nonsense syllables was negatively affected by attempting to learn new nonsense syllables a short time afterwards. Memory, however, was not affected if time was allowed to pass after learning. Based on this finding the authors proposed that memories are initially preserved and then slowly consolidate over time. Further developments in this scientific field arrived with the "sequential dual trace" model of memory consolidation as proposed by Hebb (1949) and Gerard (1949; 1955). According to this view, an experience produces a labile short term memory (STM) process that promotes the retention of recent experiences and initiates the development of a more slowly developed long term memory (LTM) trace. According to Hebb (1949) an appreciable time is necessary for a structural growth to consolidate a fleeting memory into a long term memory. In the initial stages memories are fragile and any new information is likely to disrupt the original learning by disrupting the preservation, and consequently the consolidation of the original information (McGaugh 2000; 2003). Both these hypotheses advocate that an initial fragile memory trace consolidates over time into LTM (McGaugh 2003). Gold & McGaugh (1975) hypothesised that there is some advantage in taking time before committing any information to permanent storage; time dependency may reflect the time during which an organism selects from all experiences those that should be committed to permanent storage. However, as McGaugh (2000; 2003) points out, it would be more accurate to regard both these hypotheses as 'single trace' consolidation hypotheses, as STM sequentially over time becomes LTM. The only difference between short and long term memory according to this model, McGaugh argues, is the strength of the memory

trace. More recent research instead indicates that short and long term memory are two distinct systems that can operate independently of one another, i.e. there can be LTM without STM, and STM without LTM (McGaugh, 2003) (see Figure 1.4).

Agranoff (1965), for example, injected the protein synthesis inhibitor, puromycin, into the brains of goldfish both before and after training. When injected after training it produced retrograde amnesia. When injected before training the fish were able to learn their task as normal, but could not remember it hours later. Therefore, protein synthesis inhibitors, although blocking memory consolidation, did not interfere with short-term memory.

Izquierdo, Barros, Souza, Souza & Izquierdo (1998) have also shown that drug manipulations can prevent memory consolidation while sparing short-term memory.

McGaugh (2003) contends that such research indicates that long and short-term memory are perhaps independent and parallel phases of memory consolidation. Research on human participants has shown that individuals trained in a visual skills task did not improve in their performance of the task until 8 hours post training. Additionally, the enhancement was even better the following day (Karni & Dov Sagi 1993). Brain imaging studies show changes in neural activity prompted following learning, continue to progress for many hours post learning (Shadmehr & Holcomb 1997).



**Fig.1.4** The consolidation of new memories into LTMs is time dependent. Short term and different stages of LTM are not sequentially linked. Time dependent stages of memory are based on independent processes acting in parallel.

McGaugh (2000, p.248)

Single-case studies, for example of the patient known as H.M. strongly suggests a short-term memory system and a long-term memory system coexist in the brain. H.M. had suffered from a severe case of epilepsy and surgeons opted to remove large areas of both parts of the medial temporal lobe, including the hippocampus, to treat the disorder. H.M.'s epilepsy significantly improved after the surgery; however, H.M. could no longer form any new explicit long term memories. Forty years after this surgery H.M. did not know his age, or where he lived, or the current date, or his own past during the last 40 years (Cohen & Eichenbaum 1993). He could not remember any new names or new faces (Squire, 1987), and could only retain new information for a few seconds. If, for example, he was presented with a photo and then it was removed from vision he would be able to say what he had just seen (LeDoux 1998). Therefore, it would seem that the long term memory formation is dependent on the medial temporal lobe region of the brain (LeDoux 1998).



### *1.3.5 The role of the hippocampus*

Kim & Fanselow (1992) administered foot shocks to rats in a particular setting and then thirty five days later put them back in the same place the foot shock was administered; typically resulting in freezing behaviour in the rats. The authors then lesioned the hippocampus in these rats at either 1, 7 or 14, or 28 days following training. The rats with a one hour post learning lesion displayed no sign of learning (i.e. no fear response was elicited). However, rats that received the lesion 28 days post learning performed as well as rats that had received no lesion at all. The rats with lesions 7 and 14 days post learning performed worse than the 28 day group but better than the 1 day group. This finding suggests the hippocampus plays a time limited role in memory consolidation, and that one month following learning the hippocampus is no longer needed for either the storage or retrieval of memories. In a study using human participants, Alkire et al. (1998) asked participants to listen to a series of non-emotional, unrelated words, while Positron Emission Tomography (PET) was used to monitor brain activity. A memory test administered the following day revealed that the number of words successfully recalled was highly positively correlated with parahippocampal gyrus activity during learning the previous day. Haist et al. (2001) concluded from fMRI imaging data that the hippocampus may well play a significant role in the process of memory consolidation for several years; whereas the neighbouring entorhinal cortex contributes for decades.

## Box 2. Aversive training tasks employed in animal research

### *Inhibitory avoidance*

Inhibitory avoidance tasks require animals to be placed in a small compartment. On leaving this compartment by moving into a nearby larger compartment, the animal receives a single low intensity foot shock. Memory is tested one or two days later and is assessed by placing the animals in the starting compartment and recording the amount of time it takes before they move into the compartment where they received the foot shock. Longer delays are considered evidence of good memory performance for the aversive stimulus.

### *Morris water maze*

This task typically consists of a circular tank of water of approximately six feet in diameter. Rats are trained to swim to a transparent non-visible marginally submerged escape platform located in a specific place in the tank. Distinctly visible landmarks, such as tables and wall charts are located on the walls throughout the room, and these can be used by the rat to navigate their way to the submerged escape platform. Alternatively, rats are trained to swim to a (non-submerged) visible or 'cued' escape platform. Hippocampal lesions impair retention performance for the submerged platform but not for the cued platform. Conversely, caudate nucleus lesions impair learning for the cued but not the submerged platform.

### *T-maze*

Rats are typically placed at the bottom of a T shaped maze and are allowed to go right or left at the top of the T. In a typical task food is placed at one end of the top alley (for example the left). The food remains in the same alley but the starting arm is switched so that so rats that were originally trained to go north, now go to the south. If rats had learned a turning response, they would turn right and enter the alley not containing the food. However, if they had learned the location of food in the room they would turn left. The majority of studies have found that animals chose to go to the place where food had been found before, rather than make the incorrect turning response.

From McGaugh (2003)

### 1.3.6 Identifying the mechanism responsible for enhanced memory for emotional events

As previously discussed, emotional events are remembered with greater clarity and detail than events of an emotionally neutral nature, but what is the mechanism responsible for this phenomenon? Are emotionally arousing events rehearsed more in our minds and with other individuals (by talking about these emotional events with others) thereby increasing our memory for these events? Or is it the distinctiveness of emotional events and not the emotion *per se* that is responsible for their increased memorability? Also, emotional events may receive greater scrutiny and this again may be responsible for the enhanced memory associated with emotional events.

However, research suggests the above factors may not in fact be responsible for the enhancing effect of emotion on memory (Reisberg & Heuer, 2004). For example, Wessel & Merckelbach (1997; 1998) found that individuals with a spider phobia had greater memory for images of spiders compared to control participants, who were not fearful of spiders. The authors argue that the images were equally distinctive for both sets of participants, therefore it was not the distinctiveness of the stimuli *per se* that was responsible for the enhanced memory but rather the fact that the stimuli were more emotionally arousing for the phobic participants than for the control participants.

Christianson & Loftus (1991) presented participants with three different types of stimuli: a) neutral, b) emotional, and c) distinctive/novel but unemotional. The neutral stimulus pertained to a story concerning a woman riding her bicycle; the emotional stimuli involved a story of a woman who suffered an injury while riding her bicycle; and the distinctive stimulus consisted of a story involving a woman carrying her bicycle on her shoulder. Memory for the distinctive and emotional stimuli showed similar patterns for peripheral

details but individuals showed enhanced memory for central details for the emotional stimulus compared to the distinctive one. This finding suggests the effect of emotion on memory is different from the effect of pure distinctiveness. Heuer & Reisberg (1990) asked one group of participants to view the emotionally arousing version of the doctor/mechanic story while other participants were instructed to view the neutral version but were asked to remember it as best they could (this condition was included so that individuals would rehearse the material in order to remember it, thus revealing rehearsal's effect on memory). Nevertheless, the group that viewed the emotional stimulus showed greater memory performance than the 'rehearsal group'; suggesting that scrutinizing and rehearsal could not explain the enhanced memory. In a similar experimental design, Guy & Cahill (1999) asked participants to view a set of emotional films and a set of neutral films. One group of participants was instructed to talk about the films they saw with other people (the rehearsal condition), a second group was instructed not to discuss the films with anyone, and a third group was instructed not to discuss the films but did actually talk to other people about the films. A surprise memory test administered one week after viewing revealed greater memory for the emotional film in all three groups. There was also no difference between the groups in the relative number of emotional and neutral film details recalled. The results suggest that rehearsal is insufficient to explain the effect of enhanced memory for emotional material. The authors proposed that there may be instead a biological process at play that 'burns' emotional memories into the brain. We shall now turn our attention to the research that strongly indicates there are specific biological mechanisms responsible for enhanced memory for emotional events.

### *1.3.7 Biological mechanism responsible for enhanced memory for emotional events*

Research indicates that the amygdala's modulation of memory consolidation in the hippocampus is the principal neural mechanism responsible for enhanced memory of emotional events (Phelps 2006). The amygdala is not believed to store declarative emotional memories but instead modulates memory consolidation in other brain regions, such as the hippocampus (McGaugh 2000; 2004). There is a vast animal literature displaying the essential role the amygdala plays in memory consolidation of aversive (thus emotionally arousing) tasks and training. Many studies have shown that low-intensity amygdala stimulation, induced after training resulted in enhanced memory for that training (Goddard 1964; McGaugh & Gold 1976). Research has also shown that lesioning the amygdala in rats impairs learning aversive, thus emotionally arousing, tasks (Cahill & McGaugh 1990; Hitchcock & Davis 1987; Kesner, Walser & Winzenried 1989; LeDoux, Iwata, Cicchitti & Reis 1988). Human studies have also shed light on the role of the amygdala in memory consolidation.

Markowitsch et al. (1994) investigated memory for emotional events in two patients with bilateral amygdala damage due to Urbach-Wiethe disease (patients C.P. & B.P.). The patients were required to complete a word stem, using stems of neutral and emotional words that had been previously presented to them. Both patients showed impaired memory performance for the emotional words compared to controls. In an additional task in which participants' memory for previously seen pictures was tested, C.P. showed greater recognition memory for neutral pictures than emotionally arousing pictures, whereas control participants showed the opposite pattern. Cahill, Babinsky, Markowitsch & McGaugh (1995) presented patient B.P. with an emotionally arousing slide show where the emotional manipulation was introduced in the middle of the presentation. This

presentation is a revision of the Doctor/Mechanic presentation used by Heuer & Reisberg (1992). The emotionally arousing story (now referred to as the Cahill slide presentation) is presented in a slide presentation format and has an accompanying audio narrative. The presentation depicts a story of a mother and her son going to visit their father at work, and while crossing a road the boy gets knocked down by a car. The emotional content is introduced in between slides 5 and 8 and includes an image of a boy's severed legs surgically reattached. The slide presentation can be partitioned into an initial neutral phase (slides 1 to 4) with an emotionally arousing mid section (slides 5 to 8) followed by the conclusion to the story (slides 9 to 11). Control participants who also viewed the presentation showed enhanced memory for the emotionally arousing middle phase of the presentation. However, B.P.'s memory was the same for both emotionally arousing and neutral material. This impairment in memory for emotional material transpired despite the fact the B.P.'s rating of how emotionally arousing the slide presentation was for him was no different to that of controls. Adolphs, Cahill, Schull & Babinsky (1997) presented the Doctor/Mechanic stimuli to two patients with Urbach- Weithe disease. Although the patients reported the emotional slides as being more emotionally arousing than the neutral slides, they did not show enhanced memory for the emotional compared to the neutral slides.

Research has also shown that unilateral amygdala damage (i.e. damage to just one amygdala) also leads to impaired memory for emotional material (Adolphs, Tranel & Denburg 2000; Labar & Phelps 1998; Denburg, Tranel & Adolphs 2001). Further evidence of the amygdala's role in memory consolidation of emotional events comes from Cahill et al. (1996). The authors employed positron emission tomography (PET) of cerebral glucose metabolism of participants as they encoded emotionally arousing material.

They found that the glucose metabolic rate of the right amygdala while viewing the emotional material was highly positively correlated with recall of that material.

### *1.3.8. The role of stress hormones in memory consolidation*

#### *1.3.8.1 Adrenaline and Noradrenaline*

The emerging model of the amygdala's role in memory consolidation is that it is part of a neurobiological system, together with stress hormones, that modulates memory consolidation of emotional events via its effect on brain areas such as the hippocampus and caudate/putamen (McGaugh 2000; Packard & Teather 1998). Substantial evidence from animal research suggests that enhanced memory associated with emotional arousal results from an activation of  $\beta$ -adrenergic stress hormone systems during, and after, an emotional experience. For example, Gold & van Buskirk (1975) showed that memory performance in rats trained in an inhibitory avoidance task is increased by low doses of adrenaline (called epinephrine in the U.S.A.). The improvement in performance was at its greatest when adrenaline was administered soon after training. Animal studies using discrimination learning, active avoidance and inhibitory avoidance tasks (see Box 2) have all found that adrenaline administered immediately after training leads to enhanced memory performance (Borrell, de Kloet, Versteeg & Bohus 1983; Gold, vanBuskirk & Haycock 1977; Introini-Collison & McGaugh 1986; Izquierdo & Dias 1983; Liang, Bennett & McGaugh 1985; Sernberg, Isaacs, Gold & McGaugh 1985; cited from McGaugh, 1992a). Research therefore suggests that adrenaline modulates long-term memory by influencing post-learning processes underlying memory storage (McGaugh 1992a). Gold & McCarty (1981) showed that animals that received a post-training dose of adrenaline had enhanced retention performance and had plasma levels of adrenaline equivalent to untreated animals given training that produced good memory performance. Additionally, Introini-Collison &

McGaugh (1986) found enhanced memory performance due to post learning administration of adrenaline one month after training. Such findings support the view that endogenously released adrenaline plays a role in enhancing memory storage (McGaugh 1992a).

Adrenaline does not cross the blood brain barrier (Weil-Malherbe, Axelrod & Tomchick 1959), therefore how does it affect memory consolidation in the brain? Research suggests that adrenaline influences memory storage by stimulation of peripheral  $\beta$ -adrenergic receptors on vagal afferents that project to the nucleus of the solitary tract (NTS) in the brain stem (McGaugh 1992a; 2000). Electrically stimulating the ascending vagus nerve immediately following learning, has been shown to enhance memory in a similar way to that produced by adrenaline (Clark, Smith, Hassert, Browning, Naritoku & Jensen 1998). Noradrenergic projections stemming from the NTS have been shown by van Bockstaele, Colago & Aicher (1998) to stimulate the amygdala and other forebrain regions. These projections may also stimulate noradrenaline release via projections that activate a structure in the lower medulla called the nucleus paragigantocellularis which in turn projects to the locus coeruleus. Gold & van Buskirk (1978a) found that the  $\beta$ -adrenergic receptor antagonist propranolol weakened the enhancing effect of adrenaline administration on retention performance in an inhibitory avoidance training task in rats. The authors also found that post-training brain noradrenaline levels were closely related to retention performance on the task. Liang, Juler & McGaugh (1986) investigated the effects of post-training administration of noradrenaline (NA) on retention performance in inhibitory avoidance training in rats. The authors found that low doses administered shortly after training enhanced retention. They also found that simultaneous administration of propranolol blocked the enhancing effect of NA administration. Intra-amygdala administration of propranolol also blocked the enhancing effects of adrenaline administration. The authors concluded that noradrenergic receptor activation in the



amygdala plays an important role in memory consolidation. Williams & McGaugh (1993) have shown that the noradrenergic projections from the locus coeruleus stimulate the amygdala and hippocampus. The above authors have also shown that a temporary drug induced deactivation of the NTS blocks the effect of adrenaline on memory consolidation (Williams & McGaugh 1993). It has also been shown that post learning administration of adrenaline into the NTS enhances memory consolidation (Williams, Men & Clayton 2000). Such evidence suggests the NTS, is an important linkage, connecting the autonomic and peripheral systems to the neural processes involved in memory consolidation (McGaugh & Roozendaal 2002). Adrenaline also triggers the release of glucose into the blood by increasing glucose output from the liver (Bennett 1999). Animal (e.g. Messier & White 1984) and human studies (e.g. Mohanty & Flint 2001) have shown a time and dose dependent effect of glucose administration on memory performance. For example, Flint & Riccio (1996) showed that glucose administered immediately after training showed a significant enhancement in memory performance for the task.

#### *1.3.8.2 Glucocorticoids*

As previously discussed, glucocorticoid release (including cortisol) is induced by the 'second wave' of the stress response. The effects of adrenaline and noradrenaline can occur within seconds, however, glucocorticoids are released after a latency time of minutes and their effects can take hours to materialize (McEwen & Sapolsky 1995). There is a vast literature, however, that suggests that glucocorticoids play a crucial role in long-term memory consolidation (Roozendaal 2000; de Kloet, Oitzl & Joels 1999). In a manner similar to that of adrenaline, low doses of glucocorticoids administered post learning have been found to enhance memory consolidation (Roozendaal, Carmi & McGaugh 1996; Sandi, Loscertales & Guaza 1997; Pugh, Tremblay, Fleshner & Rudy 1997; Cordero &

Sandi 1998). Additionally, blocking the cortisol stress response using metyrapone (a cortisol synthesis inhibitor) negates the enhancing effect of post training administration of adrenaline on memory performance in an inhibitory avoidance task (Roozendaal, Carmi & McGaugh 1996; Liu, Tsuji, Takeda & Matsumiya 1999). Therefore, the adrenergic and glucocorticoid systems seem to interact to influence memory consolidation (McGaugh & Roozendaal 2002). Glucocorticoid release also increases the level of glucose in the blood by increasing the output of glucose from the liver, decreasing the absorption of glucose into peripheral tissues and by triggering the release of glucogenic amino acid (Flint 2004). As described previously, research has shown an enhancing effect of post learning administration of glucose on memory formation (Flint & Riccio 1996).

Unlike adrenaline, glucocorticoid hormones freely enter the brain. The hippocampus has a high density of glucocorticoid receptors (Reul & de Kloet 1985). Administration of a glucocorticoid agonist into the dorsal hippocampus post training has been found to enhance memory consolidation (McGaugh 2000). One of the ways cortisol is thought to exert its influence on memory consolidation processes is by binding to glucocorticoid receptors (GRs), present in great quantity in hippocampal neurons (Herman et al. 1989; Van Steensel et al. 1996). Sandi et al. (1997) found that improved memory performance in a Morris water maze task when cortisol was administered immediately post training. The same authors also found that reducing the water temperature (that the rats had to swim through) thus inducing a stress hormone response similar to that of a dose of exogenously administered cortisol (a dose large enough to induce a memory enhancing effect) also improved retention performance in the task. Further research employing Morris water maze tasks revealed that administration of GR antagonists prior to, or immediately after, a 1<sup>st</sup> training trial lead to impaired retention performance in follow up sessions one day later (Oitzl & de Kloet 1992; Roozendaal & McGaugh 1997b).

Table 1.1 Treatment effects on memory consolidation and amygdala noradrenaline release

Treatment	Neuroreceptor effect	Memory Effect	Amygdala noradrenaline
Adrenaline	Adrenoceptor Agonist	Enhances	Increases
Picrotoxin	GABAergic antagonist	Enhances	Increases
Muscimol	GABAergic agonist	Impairs	Decreases
Naloxone	Opiate receptor antagonist	Enhances	Increases
Beta-endorphin	Opiate receptor agonist	Impairs	Decreases
Propranolol	$\beta$ -adrenergic receptor antagonist	Impairs	Decreases
Inhibitory avoidance training			Increases

(adapted from McGaugh 2003)

### 1.3.8.3 Stress hormones & memory for emotional events in humans

Cahill, Prins, Weber & McGaugh (1994) investigated the effect of propranolol on long-term memory consolidation for an emotionally arousing and a neutral but closely matched story. The emotionally arousing version is known as the Cahill slide presentation, and consists of 11 slides and an accompanying audio narrative (see p. 26 for full description). The neutral version is closely matched but contains no emotionally arousing material. The drug administration in this study was found to significantly impair memory for the emotionally arousing but not for the neutral story. Importantly, the memory performance of the placebo group was significantly better than that of the propranolol group for questions pertaining to the 2<sup>nd</sup> phase of the arousal story, the critical phase in which the emotional elements were introduced. Nielson & Jensen (1994) induced physiological arousal in participants by asking them to squeeze a hand dynamometer after viewing target words embedded in a story. The authors found that arousal enhanced heart rate and memory for these target words. Nielson, Radtke & Jensen (1996) induced physiological arousal in participants by asking them to increase muscle tension (again using a hand

dynamometer) in order to see how physiological arousal might affect memory consolidation of a list of highly imageable nouns. The authors reported that arousal induced shortly after learning did enhance memory consolidation for the words. Van Stegeren, Everaerd, Cahill, McGaugh & Gooren (1998) investigated the relative importance of central versus peripheral beta adrenergic receptor activation for memory consolidation of emotional events. The authors administered propranolol or nadolol to participants before they viewed an emotionally arousing slide presentation. Propranolol can cross the blood brain barrier, however, nadolol can only do so to a considerably lesser degree, and therefore this manipulation was ideal to determine the effects of central versus peripheral beta-adrenergic receptor activation on memory consolidation of emotional material. Propranolol but not nadolol administration impaired memory for emotional material suggesting that the enhancing effect of emotion on memory is not necessarily dependent on activation of peripheral beta-adrenergic receptors.

However, in a similar experimental design, O' Carroll, Drysdale, Cahill, Shajahan & Ebmeier (1999a) did not find an impairing effect of propranolol and nadolol on memory consolidation of emotional material. O' Carroll, Drysdale, Cahill, Shajahan & Ebmeier (1999b) administered yohimbine (a central noradrenergic activator), metoprolol, (a central noradrenergic activity blocker) or a placebo to participants before viewing an emotionally arousing slide presentation. The authors found that yohimbine administration enhanced, while metoprolol administration impaired, memory for emotional material, relative to placebo. This finding supports the view that noradrenergic system activation enhances, and blockade impairs memory consolidation for emotional material. Papps, Shajahan, Ebmeier & O'Carroll (2002) then used a noradrenaline re-uptake inhibitor (reboxetine) to stimulate the central noradrenergic system in participants who were asked to view the same emotionally arousing slide presentation. The authors however, did not find an

enhancement in memory for emotional material as a result of taking this drug. In another study employing the use of yohimbine, Southwick, Davis, Horner, Cahill, Morgan III, Gold, Bremner & Charney (2002), asked twenty one participants to view an emotionally arousing slide presentation, following which participants received yohimbine or a placebo. Although the authors found no difference in memory for the presentation between the two groups, they did find that central and peripheral noradrenaline activation was positively correlated with enhanced memory for emotional material.

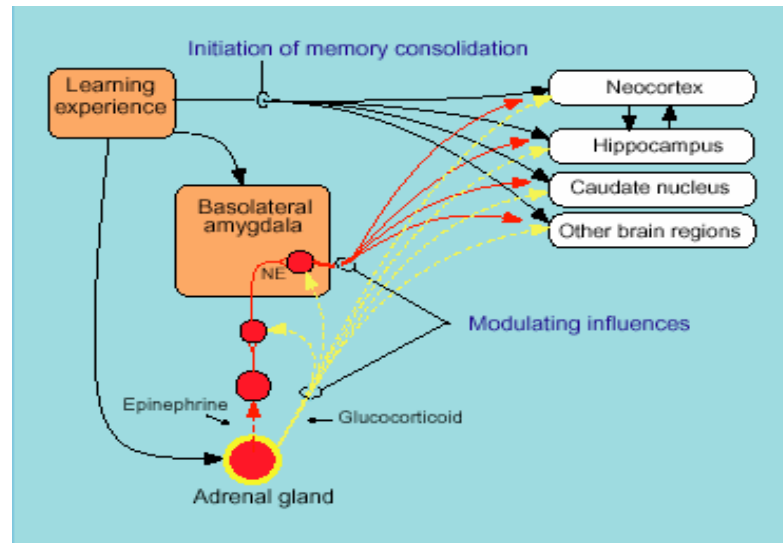
In opposition to the 'now print' metaphor of memory consolidation (after an arousing event the brain 'prints' all events immediately preceding and following the event (Livingston 1967)), Cahill & Alkire (2003) found that post learning arousal *interacted* with the degree of emotional arousal at initial encoding of the emotional stimulus to enhance memory for the emotional material. In this study participants viewed a series of 21 slides, immediately after viewing the slides they received an infusion of saline or adrenaline. Adrenaline dose-dependently increased memory for the "primary" slides (first three in series) but did not affect memory of the "recent" slides (last three in series). A second experiment involving different participants revealed significantly elevated electrodermal responses to the "primary" slides. The authors interpreted these findings as suggesting that stress hormones such as adrenaline may interact with the degree of arousal at initial encoding of information to modulate memory consolidation processes for that information. More direct support for this hypothesis was found with by Cahill, Gorski & Le (2003) who used the Cold Pressor Stressor (CPS: this involves participants having to submerge their hands in ice cold water and is associated with an increase in the release of stress hormones) or a control procedure with subjects immediately after they viewed slides of varying emotional content. A memory test one week later revealed that the CPS group, which had significantly elevated cortisol levels, had enhanced memory for the emotionally arousing

slides compared to the control group. Memory for neutral information, however, did not differ between the two groups. Buchanan & Lovallo (2001) found that *pre-learning* administration of cortisol enhanced long-term memory for relatively arousing pictures but not for relatively neutral ones. A pre-learning administration however, does not isolate the effects of cortisol on memory consolidation processes as the cortisol administration may also modify attention to the stimuli. A large body of literature suggests that pre-learning cortisol administration has an impairing effect on general memory (de Quervain et al. 2000; Kirschbaum et al. 1996; Newcomer et al. 1999). However, pre-learning cortisol administration can also affect attention, and these findings may be a result of impaired attention towards a stimulus rather than impaired memory for the stimulus.

Some research, however, has also shown that emotion does not always enhance memory for events (e.g. Clifford & Scott 1978; Clifford & Hollin 1981; Loftus & Burns 1982). For example, Loftus & Burns (1982) found diminished memory for an emotionally arousing film (involving a bank robbery) compared to a closely matched less emotionally arousing presentation. Additionally, some studies have reported a disassociation between memory enhancement and the physiological mechanisms thought to be responsible for this phenomenon. For example, Gore, Krebs & Parent (2006) found an enhancing effect of emotional arousal on memory but failed to find an increase in cortisol and glucose level as a result of this arousal. The authors concluded that other mechanisms may be at play regarding emotions effect on memory consolidation. Conversely, Scholey, Laing & Kennedy (2006) failed to find an enhancing effect of emotion on memory but did report that viewing the emotional material resulted in increased glucose levels. Quevedo, Anna, Madruga et al (2003) also failed to find an enhancing effect of emotion on memory, one hour post viewing the emotional material. The above examples illustrate the complexities involved in determining exactly what mechanisms are responsible for the enhancing effect

of emotion on memory that is so often reported in the literature. Scholey et al and Gore et al's (2006) findings raise the possibility that emotional stimuli may act as powerful "attention grabbing magnets", and this increased attentional allocation, rather than the emotion *per se*, may be responsible for the enhancing effect on memory. However, as described earlier, emotionally arousing stimuli have been shown to enhance memory compared to 'idiosyncratic' attention grabbing stimuli (Christianson & Loftus (1991). Also a vast animal and human literature implicates a role for stress hormone activation (in response to emotional arousal) in the enhancing effect of emotion on memory. Chapter 2 of this thesis will further examine how stress hormone activation affects memory consolidation of emotional events, and more specifically, whether arousal at encoding interacts with stress hormone activation to enhance memory.

For a summary of the effects of stress hormones on memory consolidation process see Figure 1.5 below.



**Fig. 1.5 Emotional experiences activate the release of stress hormones from the adrenal medulla and adrenal cortex. They also trigger the release of in the NA (called NE in diagram) in the BLA. Memory consolidation is enhanced via the amygdala enhancing neuroplasticity in other regions of the brain including the hippocampus. McGaugh (2000, p.248)**

### 1.3.9 Sex differences in memory consolidation

Cahill, Haier, White, Fallon, Kilpatrick, Lawrence, Potkin & Alkire (2001) recorded participants' regional cerebral glucose as they watched an emotionally arousing film and a matched neutral film. The authors found that enhanced activity of the right amygdala was correlated with enhanced memory for emotional material in males. Conversely, enhanced activity of the left amygdala in females was associated with enhanced memory for the emotional material. Cahill & van Stegeren (2003) found  $\beta$ -adrenergic blockade using propranolol leads to an impairment in recall of central details of an emotional stimulus in males and impairment in recall of peripheral details in females. Their findings provide support for the hypothesis that emotional arousal enhances long-term memory for central



information in men, and enhances long-term memory for peripheral details in women. Cahill, Gorski, Belcher & Huynh (2004), using emotional images taken from the International affective picture system (IAPS), found no differences in recall of either central or peripheral story information between males and females. Cahill et al. (2004) were also interested in whether the composite sex related personality traits of participants differentially related to memory performance. The Bem Sex Role Inventory was used to independently assess masculine and feminine traits for each participant. ‘Bem males’ (those participants with masculine personality types) but not ‘Bem females’ (participants with feminine personality types), showed enhanced recall of central emotional information. However, ‘Bem females’ and ‘Bem males’ did not differ in their recall of peripheral emotionally arousing details. Nevertheless, for Cahill et al. (2004) the findings suggested that sex related traits, rather than actual sex *per se*, may be a better predictor of recall for central and peripheral details. The effect of sex (and sex related traits) on memory performance for central and peripheral details will also be investigated in Chapter 2 of this thesis.

#### *1.3.10 Emotional feedback from the body to the brain*

“Common sense says...we meet a bear are frightened and run...The hypothesis to be defended here is that the order of the sequence is incorrect...the more rational statement is we feel afraid because we tremble” (James 1884, p. 1065-6)

The James-Lange theory of emotion contends that the central representation of states of peripheral bodily arousal bestows emotional colour to bodily sensations that would otherwise be emotionless bodily sensations (James 1884). James proposed that “Our feelings... of the changes as they occur *is* the emotion” (James, 1884, p.189-190).

Schachter (1964), who is also an influential theorist on emotion, also contends that the experience of emotion “is positively related to physiological arousal (p.65). Therefore, according to this assertion individuals with greater sensitivity to their own visceral arousal should experience emotions more intensely than less sensitive individuals (Wiens, Mezzacappa & Katkin 2000). Wiens et al. (2000) produced evidence in support of this theory by finding that individuals adept at detecting their own heartbeat (thus more viscerally aware) reported more intense emotions in response to emotional stimuli than individuals poor at detecting their own heart beat. Additionally, Critchley et al. (2000a;b) have shown that bodily responses mediated by the autonomic nervous system, such as heart rate, blood pressure and sweat gland activity are related to alterations in regional cerebral activity, thus indicating that emotions are associated with the representation of bodily responses. The influential neuroscientist Antonio Damasio also contends that peripheral arousal plays an important role in the generation and experience of emotion (1994; 1999). Recently Vianna, Weinstock, Elliot, Summers & Tranel (2006) investigated whether patients with Crohn’s active (CA) disease would have increased feelings in response to viewing emotional stimuli compared to matched controls. CA disease patients have an inflamed gastrointestinal tract that induces heightened sensitivity, meaning these patients have increased feedback from the gastrointestinal system to the central nervous system. The authors therefore predicted that these patients would have more intense feelings when presented with an emotional stimulus than normal matched controls. Indeed Vianna and colleagues did find that CA patients showed increased subjective arousal in response to negative emotional stimuli compared to controls. Additionally they also found that CA patients displayed increased EEG activity while view the emotional stimuli and this activity was positively correlated with arousal ratings.

In spinal cord injury (SCI) in which there is a complete severing of the spinal cord, there is a decoupling of the body from the brain. In such circumstances, one would predict (based on the above theory) SCI patients to experience emotions less intensely due to this reduced feedback from the body to the brain. SCI therefore offers a significant insight into the importance of bodily feedback in the generation of emotion (Nicotra, Critchley, Mathias & Dolan 2005). Damasio (1999, p.289) draws on research of SCI's effect on emotion to support his very influential view on the mechanics of emotional arousal: stating "all the surveys of patients with spinal cord damage ... have revealed some degree of impaired feeling as one should have expected given that the spinal cord is a *partial* conduit for relevant body input." When making this assertion Damasio relies largely upon the work of Hohmann (1966) and Montoya & Schandry (1994). Damasio (1999, p289) goes on to assert "one undisputed fact emerged in these studies: the higher the placement of damage in the spinal cord, the more impaired feeling is."

Hohmann's (1966) study is the cornerstone for this now prevailing view on the effect of spinal cord injury on affective functioning. For this study Hohmann interviewed 25 patients with spinal cord injury, and asked them to compare emotional feelings as experienced before injury with equivalent post-injury experiences. The patients reported experiencing a decline in the intensities of feelings of anger and fear, with the decline in intensity more marked the higher the lesion (higher lesions result in more acute decreases in neural feedback from the body to the brain). The latest 6<sup>th</sup> edition of the undergraduate Psychology textbook "An Introduction to Brain and Behaviour", (Kolb & Whishaw 2005) reaffirms the conclusion drawn by Hohmann by describing how the emotional loss is greater the higher the lesion is on the spine. Montoya and Schandry (1994) also reported impaired emotional experience and heartbeat perception in patients with spinal cord injury.

If spinal cord injury reduces the capacity to be emotionally aroused in response to an emotional event, one might expect people with spinal cord injury to have reduced memory for emotional events compared to healthy individuals. Recent functional anatomical research points to an afferent neural system involving the lamina 1 spinothalamocortical pathway, representing all aspects of the physiological condition of the body, which enables us to perceive feelings, mood, energy levels, stress and disposition (Craig 2002). Craig (2002) proposes that this system might offer an underpinning for subjective feelings, emotion and self-awareness. Lack of such feedback during an emotional event may diminish feelings of emotional arousal and thus stress hormone activation, which research shows, is important in memory consolidation of emotional events (McGaugh 2000). Therefore, investigating memory consolidation for emotional events in individuals with spinal cord injury may elucidate further the mechanisms involved in memory consolidation processes. This issue will be explored and discussed in Chapter 3.

#### *1.4 Ultimate explanations for enhanced memory for emotional material*

As outlined by authors such as Nesse (1990), Damasio (1994; 1999) and Rolls (1990; 1999a; 2000), from an *ultimate* perspective, emotions can be regarded as chemical and neural responses, fashioned by natural selection, that increase fitness in certain situations. This view also outlines that the biological function of emotions is to increase the capability to deal with both aversive and agreeable stimuli present in the environment (Nesse 1990; Damasio 1999). Furthermore, each emotion should relate to a particular kind of adaptively significant situation that has occurred repeatedly during the course of evolution, and increase an individual's chances of coping with that type of situation successfully (Nesse 1990; Damasio 1999). Males and females have faced different obstacles to their reproductive success in the ancestral past and, thus, may have developed differing types of

emotional states and reactions to deal with these different kinds of adaptively significant problems.

#### *1.4.1 Do memory and emotion interact in an adaptive fashion?*

Memory also seems to serve an adaptive function: McGaugh (2000; 2003) states that there is no convincing argument to conclude that the biological system that is the human brain could not rapidly create lasting memories, however, the evidence suggests our brains do not. Thus, according to McGaugh, memory consolidation must serve an important adaptive function(s). The evidence suggests that the slow process of memory consolidation itself is adaptive: allowing neurobiological processes taking place shortly after learning to influence the strength of memory traces (McGaugh, 2000; 2003). Having greater memory for stimuli that elicit emotional arousal is adaptive as it ensures this information is available when needed in the future (McGaugh et al. 2000; Rolls 2000). However, males and females have faced different selective pressures in the evolutionary past, i.e. they have faced different threats to their survival and reproduction. If the memory and emotion interact in an adaptive fashion, then one would expect males to have better memory than females for stimuli that have posed a greater threat to *their* reproductive success. Likewise, one would expect females to have enhanced memory for stimuli that have posed a greater threat to *their* reproductive success. By investigating these questions we are investigating the *ultimate* function of memory and emotion (i.e. the survival or fitness advantage it confers to individuals). Evolutionary biologists and psychologists have identified and described key differing selective pressures that have faced males and females (e.g. Symons 1979; Trivers 1972; Daly & Wilson 1983; Buss 1992). These differing selective pressures have been argued to have shaped the sexes psychological predisposition differently and in a manner that allows them to tackle the adaptive problems

they face. This thesis is interested in whether memory and emotion interact in an adaptive fashion for both males and females, thus allowing them to deal with the selective pressures they have faced in the ancestral past and perhaps still do face today. Therefore we will discuss some of the key fitness problems that have faced males in females in the ancestral past and test whether their memory consolidation system has evolved to *serve* the adaptive problems they have faced. Males and females have been hypothesised to have been subjected to the following selective pressures:

The pressure for:

- a) Females to show greater fear to physical danger
- b) Females to be physically attractive & protect their sexual reputation
- c) Males to achieve and maintain social status
- d) Females to show greater distress concerning a mate's emotional infidelity, and for males to show greater distress concerning a mate's sexual infidelity.

Males and female have also faced a selective pressure that has bore on each of them equally: the problem of detecting cheaters or 'free-riders' (Dunbar, 1999). Humans have lived in social groups for thousands of years and thus have run the risk of being deceived and exploited by their conspecifics. It has been argued that such an adaptive problem has selected for a cognitive mechanism that is able to detect other individuals as they attempting to deceive us (Cosmides and Tooby, 1992). This thesis is also interested in whether memory and emotion interact in to enable enhanced memory consolidation for 'liars' compared to individuals telling the truth. This capacity would be an adaptive capacity for humans considering we evolved in large social groups (Dunbar 1999).

The remainder of this chapter will examine these selective pressures that males and females (and humans as a whole) have faced and hypothesise how memory and emotion should interact to confront these adaptive problems.

#### *1.4.2 Differing selective pressures facing males and females*

##### *1.4.2.1 The pressure for females to avoid risk and danger*

During the course of evolutionary history, an offspring's chances of survival were much more dependent on the presence of his or her mother in their child-rearing rather than the father (Campbell 1999). According to Campbell (1999), this pressure on the mother to be present for their offspring (as her presence is more important for her own reproductive success) forms the basis for the contention that females should be more concerned with avoiding risk taking behaviour and staying alive than males. Females also have a greater relative certainty than males of producing offspring during their lifetime; they also do not have to worry about paternity uncertainty. During the ancestral past males could never be certain of paternity; and modern evidence indicates that between 9% and 30% of offspring are not biologically related to their fathers (Bellis & Baker 1990; Baker & Bellis 1995). Therefore, from an evolutionary perspective, females know that time and resources spent raising offspring is not time and resources 'wasted'. Congruent with this position is that females are found to spend a considerably greater deal of time and energy rearing offspring than males (Campbell 1999). According to Campbell (1999), the female's presence for offspring rearing was made all the more vital due to the nature of gestation and birth: the birth canal in humans narrowed during the course of evolutionary history due to the evolution of bipedalism, requiring infants to be born relatively immaturely and thus

needing a lengthier phase of dependency (Foley 1996; Lancaster & Lancaster 1983; Peccei 1995).

Campbell (1999) also points to orphan survivorship data to support the hypothesis that a mother's presence is more important for infant survival than a paternal presence: for the Ache hunter gatherer tribe of Paraguay, a mother's death increases age specific child mortality five fold, compared to three times the increase caused by a father's death (Hill & Hurtado 1996). The above evidence suggests a mother's presence is much more crucial to offspring survivorship than a father's. Considering this, Campbell (1999) argues that females should have evolved a psychology in which greater 'weight' is given to the costs of physical danger (compared to males). According to Campbell (1999), the mechanism by which females 'weigh' costs of a given encounter is fear. Campbell posits that when confronted with the same level of objective risk of danger, females will experience greater fear than males, particularly when the threat is to their bodily integrity.

There is plentiful evidence to support this conclusion. Campbell (1999) believes looking at the prevalence of phobic reactions amongst the sexes is a fruitful line of investigation as their foci are believed to relate to specific dangers faced by humans during the ancestral past. This evidence indicates that females have a higher prevalence of panic disorder (American Psychiatric Association 1994), animal phobias (e.g. snakes, insects, mice and dogs), and phobias of injury, blood and medical procedures (Marks 1987). The cost of engaging in aggressive acts for males, however, is less costly, than it is for females. A male's reproductive success can increase significantly following a successful aggressive encounter due to the relationship between status and reproductive success (Low 2000). Indeed, research on sex differences in 'sensation seeking' shows that more males take part in risky forms of sensation seeking (Rosenblitt, Soler, Johnson, & Quadagno 2001).



Additionally, more males than females are involved in dangerous sports, crime and military combat (Zuckerman 1994).

Indeed, neuropsychological research also suggests that females are more fearful of harmful stimuli than males. Wrase et al. (2003) has shown that women have stronger brain activation for emotionally negative pictures in the anterior and medial cingulate gyrus.

The growing literature on sex differences in memory consolidation suggests that females may have enhanced memory for emotionally threatening situations. Canli, Desmond, Zhao & Gabriel (2002) used fMRI to assess brain activation of twelve men and twelve women as they rated their experience of emotional arousal in response to neutral and emotionally negative pictures. Highly emotional pictures were remembered better by females than by males. The sexes also activated different neural circuits to consolidate the emotional stimuli successfully. The above research therefore suggests that males and females do differ in their processing of emotionally threatening material and in a manner that is congruent for their survival and genetic fitness. We will now address further selective pressures that have faced the sexes and describe how they may have affected their memory consolidation for certain types of emotional events.

#### *1.4.2.2 The pressure for females to be physically attractive and protect their sexual reputation*

Reproductive success for males (more than females) is limited by the number of fertile females they can gain sexual access to (Symons 1979; Trivers 1972; Clutton-Brock 1991). Considering female fertility is at its greatest around the mid twenties, and gradually fades away by the age of forty-five (van Noord-Zaadstra et al. 1991; Menken et al. 1986), natural selection should favour males who prefer to mate with fertile (i.e. youthful females). In the

ancestral past and even today age and thus fertility must be deduced by physical features such as smooth, unblemished skin, and lustrous hair (Buss 1992). Female attractiveness is also positively correlated with oestrogen level (Law Smith et al. 2006) which in turn is positively correlated with female fertility (e.g. Baird et al. 1999). The physical attractiveness of females should therefore be vital for males, in their selection of opposite sex mating partners (Buss 1987; 1992). Female reproductive success is not curtailed by the problem of acquiring youthful males as male fertility remains high into the fifties and sixties (Buss 1992).

Another important concern for males is the sexual trustworthiness or promiscuity of a prospective mate. Due to the risk of cuckoldry, males who showed a preference for a 'sexually loyal' female would have enjoyed greater reproductive success and this preference should therefore be evident today (Dickemann 1981). Research supporting this, showed males displayed greater emotional distress at the thought of their partner having sexual intercourse with another man, but not another female (which could not lead to cuckoldry) (Sagarin et al. 2003).

The evolutionary view on male mate preferences is strongly supported in the literature. For example, a cross cultural survey sampling thirty-three countries on six continents found males put greater value on youth and physical attractiveness in prospective mates than females (Buss, 1989a). Sixty two percent of the cultures sampled showed males valued chastity in a potential opposite sex mate more than females, whereas none of the samples showing a stronger female than male preference for chastity in a partner (Buss 1989a). Subsequent cross cultural research again revealed males show a greater preference for youth in a potential opposite sex mate (Kenrick & Keefe 1992). The above evidence outlines how and why youth, physical beauty, and a 'trustworthy' sexual reputation are

traits that are sought after in females by males. It is therefore not surprising that research indicates females compete with one another over such traits. We will describe this research shortly; first we will turn our attention to evolutionary pressures that specifically affect males more so than females.

#### *1.4.2.3 The pressure for males to achieve and maintain social status*

Evolutionary theory dictates that females should favour males with the ability to obtain and share resources, thus providing her and her future offspring, with territory, food and protection (Trivers 1972). Such resources provide an immediate advantage to the female and her offspring, and enhance the reproductive possibilities for her offspring (Trivers 1972). Research on the Kipsigis pastoralists in northern Kenya revealed that females looking for a marriage partner show a preference for male grooms that have the most land available to share (Borgerhoff Mulder 1990). However, humans often mate at ages before a male's potential resources are fully known, therefore, cues suggesting a male will attain high social status (enabling him to accrue resources), should be favoured by females (Buss 1992). This hypothesis is backed up with research showing that females favour dominance traits such as the propensity for 'heroic' risk taking (Farthing 2005), physical size (Graziano et al. 1978; Gillis & Avis 1980) and self confidence (e.g. Botwin, Buss & Shackelford 1997), all cues to a male's social status (Ellis 1992). Additional evidence for the female preference for high status is that high-ranking males have increased reproductive success in more than one hundred well studied societies (Low 2000). Additionally, females in seven studies within the United States and within 36 of 37 cross-cultural samples, placed greater value on the potential earning capacity of a potential mate than did males (Buss 1989a). Recent research looking at the contemporary United States

reveals that high income males report greater frequency of sexual intercourse and produce more offspring than lower income males (Hopcroft 2006).

#### *1.4.2.3.1 Implications for intrasexual competition*

Intrasexual competition refers to competition between members of one sex for sexual access to members of the opposite sex (Fisher 2004), with mate preferences in one sex driving intrasexual competition in the other sex (Darwin 1871). Therefore, one of the predictions is that females will compete with one another to appear physically attractive. Fisher (2004) showed that females at their most fertile, (a time when it is more critical for them to select a mate of good quality) were more derogatory when rating the faces of other females for attractiveness. Luxen, Fons & van de Vijver (2006) showed that in the context decision making regarding the hiring of applicants; females showed a preference for females of low attractiveness over those rated as more attractive. Also females, more than males, enhance their appearance with techniques such as wearing makeup, tanning, and wearing revealing clothes (Buss 1992). Males, on the other hand, should compete with one another for cues indicating they are of high social status. Research supports this conclusion, showing males (more than females) use resource displays and status cues (e.g. “flashing money and expensive status symbols) when attempting to attract a mate (Buss 1992; Lycett & Dunbar 2001).

#### *1.4.2.3.2 Implications for memory and emotion*

If , a) emotions act as guiding mechanism helping humans behave in a manner adaptive to their survival and, b) memory and emotion interact in an adaptive fashion; then one would expect males to be more offended and thus emotionally aroused at being labelled with

characteristics that suggest they are of low social status (or unable to achieve high status). Consequently one would also expect males to have enhanced memory for stimuli implying they were of low social status. Similarly, females should be more offended, and thus more emotionally aroused, and have greater memory for stimuli labelling them as being physically unattractive and sexually untrustworthy. This thesis aims to test these hypotheses and predictions in chapter 4.

#### *1.4.3 Differing selective pressures impacting on males and females regarding infidelity*

The innate module theory of sexual jealousy argues that men are predisposed to be upset by a mate's *sexual* infidelity, whereas women are predisposed to be upset by a mate's *emotional* infidelity (e.g. Buss 2003). This hypothesis is derived from theory proposing that males and females have been subjected to different selective pressures during evolutionary history (e.g. Symons 1979; Daly, Wilson & Weghorst 1982). For males, a partner's sexual infidelity was a major adaptive challenge, one which could mean investing resources in unrelated offspring, thus impeding one's own reproductive success. As a solution to this adaptive challenge, males evolved an innate jealousy mechanism (JM) specifically designed to detect and react to a mate's sexual infidelity (Buss 1995). Females, on the other hand, did not risk investing in unrelated offspring but did, however, risk losing investment in their offspring if their partner formed a strong emotional attachment with another female and therefore channeled his resources to her. To solve this adaptive challenge it is argued females evolved an innate JM specifically designed to detect and react to a partner's emotional attachment to another female (Buss 1995). There is a vast literature to support this theory.

The majority of this evidence comes from studies using a forced-choice hypothetical scenario designed by Buss, Larsen, Westen & Semmelroth (1992). In this seminal study Buss and colleagues asked male and female undergraduate students to choose which triggers more distress: the thought of their partner forming a deep emotional attachment with a member of the opposite sex or the thought of their partner having sexual intercourse with a member of the opposite sex. Significantly more males reported finding the latter proposition more distressing, with significantly more females finding the former proposition more distressing. This forced choice paradigm has been very fruitful in finding support for the innate module theory of sexual jealousy. For example, Pietrzak, Laird, Stevens & Thompson (2002) found 73% of male undergraduates reported greater distress over their partner's potential sexual infidelity, whereas only 4% of the female undergraduate sample selected that option. Ninety six percent of females reported greater distress over their partner's potential emotional infidelity, whereas only 27 % of males chose this option. Males also reported a significantly stronger experience of anger, rage, and betrayal while imagining sexual, compared to emotional infidelity, whereas females reported a significantly stronger experience of anger, anxiety and fear while imagining emotional, rather than sexual, infidelity. Studies using U.S. participants frequently report about 75% of females finding emotional infidelity more distressing compared to between 40% and 60% of males (e.g. Desteno & Salovey 1996; Harris & Christenfeld 1996a; cited in Harris 2003a). Research has also found cross cultural gender differences in jealousy, with Fernandez, Sierra, Zubeidat, Vera-Villarroel (2006) reporting the hypothesized sex differences in a sample of over five hundred Chilean and Spanish students.

In a more recent replication of Buss et al.'s (1992) seminal study, decision time was recorded as participants were asked to decide which type of a partner's imagined infidelity would upset them more: sexual or emotional (Schutzwohl 2004). Males took less time

when selecting sexual infidelity and females less time when selecting emotional infidelity. According to Schutzwohl (2004), this faster processing time for choosing what the authors call the 'adaptively primary infidelity type' is due to activation of their sex-specific jealousy mechanisms. Conversely, males who choose emotional infidelity and females who chose sexual infidelity, as the more distressing aspect, needed to engage in extra effortful and rational considerations of the possible tradeoffs of the two choices. The author also asked participants to decide how hard it would be to forgive their partner, and how likely they would be to break up with their partner, depending on whether the infidelity was emotional or sexual. Responses to this line of questioning revealed that males found it more difficult to forgive, and were more likely to end a relationship due to a partner's sexual, rather than emotional, infidelity. Schutzwhol & Koch (2004) set out to investigate to what degree the hypothesized 'jealousy mechanism' is a content, and sex-specific information processing device. The authors asked participants to listen to cues either diagnostic of emotional or sexual infidelity that were embedded in a narrative referring to one's own relationship. A surprise free recall memory test revealed males preferentially recalled cues to sexual, and females, cues to emotional infidelity. Schutzwohl (2005) presented a succession of either cues to emotional or sexual infidelity (depending on the condition) to participants and asked them to indicate when they felt their first pang of jealousy and also when the intensity of the experience becomes intolerable. After the first pang of jealousy had been elicited males needed significantly fewer cues than females to reach the second threshold, when listening to cues to sexual infidelity. Females, on the other hand needed significantly fewer cues to reach the second threshold from the first, when listening to cues to emotional infidelity. Other researchers have looked at actual homicide statistics to argue for innate sex differences in jealousy between the sexes. In their review of homicide data; Daly, Wilson & Weghorst (1982) concluded

that jealousy does appear to be a precipitating factor in murder across many cultures, and that males kill out of jealousy more often than females.



Panel from a mural painted in 1936 by Thomas Hart Benton for the House Lounge in the Missouri State Capitol illustrates the story of Frankie and Johnny.

Frankie and Johnny were lovers  
O Lordy, how they could love  
They swore t' be true to each other  
Just as true as th' stars above  
He was her man but he done her wrong

Frankie took a cab, at th' corner  
Says, driver step on this cab  
She was just a desperate woman  
Gettin' two timed by her man  
He was her man but he's doin' her wrong

Frankie got out at south Clark Street  
Looked in a window, so high  
Saw Johnny man, a lovin' up  
That high brow, Nellie Bly  
He was her man but he done her wrong

Johnny saw Frankie a comin'  
Out th' back door he did scoot  
But Frankie took aim with her pistol  
An' th' gun went roota-toot-toot  
He was her man but he done her wrong

**Fig. 1.6.** Poem depicting the story of 'Frankie and Johnny' (Harris 2004, p. 68)

Studies have also used psychophysiological measures to test the innate modular view of sex differences in jealousy. Buss, Larsen, Westen & Semmelroth (1999) recorded Galvanic Skin Response (GSR) activity, heart rate (HR), and electromyographic (EMG) activity of the brow region of the face, while participants imagined the two types of infidelity. GSR and HR are measures of activity of the autonomic nervous system which is involved in the 'fight or flight' response and is thus a good indicator of emotional distress. EMG activity of the brow region of the face was chosen as furrowing of the brow occurs regularly in facial displays of unpleasant emotion (Fridlund, Ekman & Oyster 1987). Males showed significant increases in GSR and HR during the sexual imagery compared



with the emotional imagery. Females, on the other hand, showed significantly greater GSR to the emotional infidelity imagery compared to the sexual infidelity imagery. There were no sex differences in brow EMG activity. Pietrzak, Laird, Stevens & Thompson (2002) measured HR, GSR, brow EMG, and skin temperature (TEMP; to detect changes in sympathetic activation) as participants imagined the two types of partner infidelity designed by Buss et al. (1992). They found that males were more responsive to sexual infidelity imagery than emotional imagery for HR, GSR, EMG and TEMP. Females were more responsive to emotional infidelity than to sexual infidelity for HR, GSR, EMG, and TEMP.

However, despite the vast support for the innate module view of jealousy, the theory does have its detractors. A recent review of the literature by Harris (2003a) points to a number of studies that fail to find the hypothesized sex differences in jealousy. For example, de Weerth & Kalma (1993) and Paul & Galloway (1994) both showed that females predict they would show greater aggression over sexual infidelity than males. Sheets & Wolf (2001) found that the sexes both rated emotional infidelity as more distressing than sexual infidelity. Nannini & Meyers (2000) also failed to find the hypothesized sex differences in jealousy. More recently, Sabini & Green (2004) only found the hypothesized effect in undergraduate students but not in a non-student sample, with the non-student sample more angered by sexual infidelity but more hurt by emotional infidelity than the undergraduate sample. In a study looking at the consequences of actual infidelity; Harris (2002) found that when asked to recall instances of a mate's actual infidelity both males and females reported focusing more on the act of emotional infidelity than on the act of sexual infidelity. Harris (2003a) also casts doubts on homicide statistics that have been used to support the 'sexual jealousy as an innate module' viewpoint. She argues that when one considers baseline homicide rates, the proportion of males that commit murder out of

jealousy does not differ significantly from the proportion of males that commit murder as a whole. She cites Daly et al.'s (1982) examination of Detroit homicides in which they reported males committed 81% of all jealousy murders but highlights that they also committed 82% of all murders, suggesting that jealousy was not disproportionately a motive for men.

Harris (2003a; 2003c) also casts doubt on the implications of the physiological studies described above (i.e. Buss et al. 1999; Pietrzak et al. 2002). These studies revealed that males did show greater GSR activity while imagining a partner's sexual infidelity, but they also showed greater activity to sexual imagery when no infidelity was involved. This finding suggests jealousy over sexual infidelity on its own is insufficient to explain the heightened GSR activity. Harris (2000) showed that females who had experienced a committed relationship showed greater blood pressure increases when imagining a mate engaging in sexual infidelity, whereas women with out such experience showed greater increases when imagining a mate engaging in emotional infidelity. Harris (2003a; 2003b) believes the theory of jealousy as an innate module is limited as it does not account for within-sex differences in jealousy. Harris's, alternative, Social-Cognitive view of jealousy proposes that cognitive appraisal plays a prominent role in the manifestation of jealousy and that individuals tend to experience jealousy in areas that are particularly important to them. Males for, example, may place greater personal importance on sexual activity than females and therefore feel more threatened by rivals in this area. Congruent with her previous research Harris (2003b) found that the sexes did not differ in the degree to which they focused on the sexual versus emotional aspects of a partner's *actual* infidelity. Also greater experience with committed relationships was positively correlated greater sexual jealousy over a mate's actual infidelity for males and females. Harris postulates that sex may become more important to an individual's self-concept within a relationship as the

relationship develops overtime. Harris (2003b) also examined how attitudes towards sex correlated with levels of distress concerning emotional and sexual aspects of a partner's infidelity, revealing that males that attached a high importance to sex experienced greater feelings of distress over a partner's sexual infidelity. More recently, Murphy, Vallacher, Shackelford, Bjorklund & Yunger (2006) found that relationship experience predicts emotional distress regarding infidelity but only for males. The authors found that males with relationship experience reported greater distress concerning a partner's sexual infidelity compared to males without such experience. Therefore research that looks at more contextual factors such as relationship experience tends to produce varied results, with many studies yielding results that are not harmonious with the innate modular view.

#### *1.4.3.1 Memory and emotion concerning infidelity*

If memory and emotion interact in an adaptive fashion, then according to the innate module view of jealousy, one would expect males to be more emotionally aroused and show enhanced memory for cues indicating their partner is being sexually unfaithful. Females, on the other hand, would be expected to be more emotionally aroused and have greater memory for cues suggesting their partner is being emotionally unfaithful. Contextual variables such as relationship experience may also modulate feelings of jealousy regarding sexual and emotional infidelity. How memory and emotion interact regarding jealousy over a partner's sexual and emotional infidelity will be investigated in Chapter 5.

#### *1.4.4 The pressure to detect liars/cheaters*

Cooperation has been an essential component in human evolution. In order to reap the benefits of living in large social groups (which humans have done since ancestral times) such as greater access to resources, protection and increased sexual opportunities; immediate rewards must often be sacrificed in order to maintain group stability (Dunbar 1999; Barrett et al. 2002)

During the course of human evolution group sizes have increased from about 60 to 80, to 150 for modern humans (Aiello & Dunbar 1993). Indeed, research concerning contemporary Western societies indicates that social network sizes still tend to average close to 150 individuals (Hill & Dunbar 2003). Within such social groups individuals who are willing to deceive others so that they accrue benefits without paying costs represent a big problem for group stability and cohesion (Dunbar 1999). In order for group living to be adaptive and remain stable over time, our ancestors must have been capable of detecting and remembering cheaters, so that appropriate action could be taken against them (Cosmides & Tooby 1992). In fact, it is argued that the problems posed by cheaters or 'free-riders' are partially responsible for the size of the human brain, which is six times larger than expected for its body size compared to the average primate (Barret et al. 2002). This theory is known as the Social brain hypothesis (Byrne & Whiten 1988). The hypothesis postulates that the ability to solve complex social problems was the drive for increased brain size among primates and most notably among humans. The ability to deceive, and avoid being deceived by other members of a social group, is thought so have selected for this increase in brain size (Barrett et al. 2002). This hypothesis contends that an 'evolutionary arms race', whereby increasingly cunning deceptive strategies used by

some individuals selected for equally clever counter-strategies in others (Barrett et al. 2002). This process has resulted in a brain of enormous complexity and one that is very adequately equipped to tackle social problems such as free riders. Other factors have been hypothesised to be responsible for the expansion of the human brain. For example, the need to keep track of one's relationships with other individuals, within an ever changing social group (Dunbar 1998a). Additionally, the 'expensive tissue hypothesis', argues that a transition to a largely meat diet (enabled by the evolution of bi-pedalism) was the trigger that allowed humans to evolve such a resource hungry organ (Aiello 1997).

The evolutionary psychologists Cosmides & Tooby (1992) hypothesize that considering humans possess specialised cognitive 'machinery' devoted to the processing of important stimuli, such as potential sexual partners, environmental threats, and food, it should be no surprise that we possess the cognitive mechanisms to enable enhanced detection and recall of 'cheaters'/ free riders'. There are numerous studies to support this conclusion.

Mealey, Christopher & Michael (1996), for example, presented participants with pictures of various faces, each with an accompanying character description (i.e. history of cheating, social status, and other personal information). A surprise memory test one week later revealed participants preferentially recognised faces of "cheaters". Oda (1997) asked individuals to participate in a series of Prisoner's Dilemma games against opponents who were either 'cheaters' or 'cooperators'. These "opponents" were photographic images of males and females with accompanying descriptions indicating whether they were 'defectors' or 'cooperators'. A memory test one week later revealed faces of 'cheaters' were remembered better. Chiappe et al. (2004) found that in a series of 'social exchange' (cooperation for mutual benefit) situations, 'cheaters' were rated as more important to remember than 'altruists'. A study by Yamagishi et al. (2003) presented participants with

facial images of people, taken at the precise moment they either cooperating or cheating, during a Prisoner's Dilemma game. Participants were not informed who were the 'cheaters' and who were the 'cooperators'. A subsequent recognition memory test revealed that faces of cheaters were remembered better than those of cooperators. This finding suggests that humans may be capable of detecting subtle visual cues that cheaters' faces give off. In fact, a review of the lie detection literature (DePaulo et al. 2003) revealed 'liars' in laboratory studies tend to fidget more, dilate their pupils more, have greater tension in their voice and, press their lips together more, than truth-tellers. Vrij, Edward, Roberts & Bull (2000) video taped a sample of nursing students as they either lied or told the truth about a video they had just seen. The speech and non-verbal behaviour of liars and truth-tellers was analysed and revealed a number of verbal and non-verbal indicators of deception. In fact seventy eight per cent of all lies could be successfully classified on the basis of non-verbal behaviour. Regarding performance at detecting individuals who are lying, Ekman & O'Sullivan (1991) showed that American Secret Service agents had better than chance probability at detecting liars from a series of video clips showing an equal number of 'liars' and 'truth-tellers'. Vrij, Evans, Akehurst & Mann (2004) investigated whether it was possible to detect lies by making rapid judgements. Participants watched fifty two video clips, half of which depicted individuals lying, the other half depicted individuals telling the truth. The authors found that participants were successful at detecting liars from truth-tellers with a seventy four per cent accuracy rating. Porter, Woodworth & Birt (2000) found that with 2 days of lie detection training, a sample of Canadian parole officers could detect 'lies' at an accuracy rate of seventy four per cent. The above research would suggest that humans may well have evolved a cognitive mechanism that allows them to detect liars.

Indeed, recent neuropsychological evidence suggests that there may be a specific module in the brain that deals with 'social contract' situations. Stone et al. (2002) found a patient with damage to the orbitofrontal cortex, temporal pole, and amygdala showed impaired social contract reasoning (e.g. if you take the benefit you must satisfy the requirement). The authors concluded that this finding suggests that information about the social world is processed separately and differently than other types of information.

However, not all research indicates individuals are good lie detectors. Vrij & Mann (2001b) carried out a study in which 65 police officers viewed six video fragments (three truthful and three deceptive) of an interview with an individual who had actually carried out a real life murder. The authors asked the officers to state after each fragment whether they thought the man was lying or not. The findings showed the officers only had 57% accuracy at detecting lies. They also found individuals that held popular stereotypical views regarding deception, such as 'liars fidget and avert their gaze, were the poorest at detecting lies.

#### *1.4.5.2 Memory and emotion regarding lie detection*

Again, if memory and emotion interact in an adaptive fashion, then based on evolutionary theory one would predict individuals to have enhanced emotional arousal to, and have greater memory for, the faces of liars (or deceivers/cheaters) than for the faces of truth-teller (honest individuals). This hypothesis and prediction will be examined in Chapter 6.

*Summary of memory and emotion from an ultimate perspective*

We have reviewed some of the fundamental selective pressures that have faced males and females and also humans as a whole (i.e. the pressure to successfully detect liars/cheaters).

We have also hypothesized how memory and emotion should interact to respond to these selective pressures. Chapters 4, 5 & 6 of this thesis will investigate these hypotheses and hopefully broaden our knowledge of the ultimate functions of memory and emotion.



**Chapter 2. Investigating the role of post-learning stress hormone activation on memory consolidation of emotional material. Additionally: examining the effect of sex on memory of emotional material.**

**Abstract**

*Aims*

To investigate whether

1. Post learning stress hormone activation (in the form of CPS stress) interacts with the degree of arousal at initial encoding to enhance memory for emotionally arousing material.
2. Males and individuals with masculine personality types will have enhanced memory for central details of emotionally arousing material.
3. Females and individuals with feminine personality types will have enhanced memory for peripheral details of emotionally arousing material.

***Method***

*Experiment 1*

Twenty four male and twenty six female students viewed an emotionally arousing slide presentation and immediately following viewing submerged one hand up to the wrist in either lukewarm (control condition) or ice-cold water (CPS condition). Thirty minutes following the slide presentation participants received surprise free recall and recognition memory tests on the slide presentation.

*Experiment 2*

Thirty six male and thirty three female students viewed an emotionally arousing slide presentation and immediately immersed their hands in either lukewarm or ice-cold water. One week later participants received surprise free recall and recognition memory tests of the slide presentation.

*Experiment 3*

Fourteen males and sixteen females from the University of Stirling population viewed an emotionally arousing slide presentation and immediately immersed their hands in either lukewarm or ice-cold water. One week later participants received surprise free recall and recognition memory tests of the slide presentation.

### *Results*

Post learning CPS stress did not lead to enhanced memory consolidation for emotional material in Experiments 1, 2 & 3. Experiments 1, 2 & 3 also failed to show enhanced memory for central details of emotional material in males and ‘masculine personality types’. All three experiments failed to show enhanced memory for peripheral details of emotional material in females and ‘feminine personality types’.

### *Conclusion*

The results of these experiments suggest that post learning stress hormone activation interacting with the degree of arousal at encoding to enhance memory for emotional material is not a robust and replicable phenomenon. The results of these experiments also suggest that sex and sex-type personality differences in memory for central and peripheral details of emotional events are also not robust and replicable phenomena.

## **2. 1 Introduction**

Chapter One provided an overview of the important role stress hormones play in memory consolidation of emotional events and specifically, how stress hormone activation may interact with the degree of arousal at initial encoding (of emotional events) to enhance memory for those events (Cahill & Alkire 2003; Cahill et al. 2003). This theory postulates that not all recent events are enhanced by this stress hormone activation, but instead only the emotionally arousing event that triggered the initial emotional arousal and the subsequent stress hormone activation. Cahill & Alkire (2003) administered adrenaline to participants immediately post viewing emotionally arousing images taken from the International Affective Picture System (IAPS; Lang et al. 1999). Cahill et al. (2003) also used images taken from the IAPS when finding an enhancing effect of CPS stress on memory consolidation for emotional material. Andreano & Cahill (2005) also found that administering CPS stress immediately after presentation of a relatively *neutral* stimulus enhanced memory for that stimulus in males but not females. Nielson & Jensen (1994)

induced physiological arousal in participants by asking them to squeeze a hand dynamometer after viewing target words embedded in a story. The authors found that arousal enhanced heart rate and memory for these target words. Nielson, Radtke & Jensen (1996) again induced physiological arousal in participants by asking them to increase muscle tension using a hand dynamometer in order to see how physiological arousal might affect memory consolidation of a list of highly imageable nouns. The authors reported that arousal induced shortly after learning did enhance memory consolidation for the words. The present study will be the first to employ both the 'Cahill slide presentation', as the 'to be remembered stimulus' and CPS stress as the 'stress hormone activator', together in the same study. This method of stress hormone activation is relatively untried in this field of research and therefore it is important for this method to be implemented in research of this nature in order to determine whether its use can reliably produce enhanced memory consolidation of emotional material.

In previous research employing the Cahill slide presentation, drug treatments such as the  $\beta$ -adrenergic receptor antagonist propranolol have been found to impair memory consolidation for emotional material (Cahill et al. 1994); while the central noradrenergic activator yohimbine has been found to enhance memory consolidation for emotional material (O' Carroll et al. 1999b). Further research is required before one can declare that 'post-learning stress hormone activation, interacting with the degree of arousal at encoding, to enhance memory for emotional material' is a robust and replicable phenomenon. This Chapter aims to test this hypothesis further.

Additionally this chapter will also investigate sex differences in memory for emotional material. As reviewed in Chapter One, neurophysiological research demonstrates sex differences in the neural processing of emotional material (Cahill et al. 2001; Canli et al. 2002; Beeman & Bowden, 2000; Fink et al. 1999). Research shows males but not females

have enhanced memory for central details of an emotionally arousing story (Cahill & van Stegeren 2003). Similarly, individuals scoring higher on masculine personality traits have shown greater memory for central details of an emotional story whereas those scoring higher on feminine personality traits showed greater memory for the 'peripheral' details (Cahill et al. 2004). This study will also examine the effects and 'Bem' sex on memory consolidation for central and peripheral details of an emotional event. Participants' heart rate and systolic pressure will also be recorded as they view the slide presentation and as they take part in the CPS stress condition. Previous research, using a stimulus similar to the one in this experiment, has found a significant heart rate reaction in response to the emotional stimulus (Heuer & Reisberg 1990). This study will also examine whether the emotionally arousing slide presentation significantly manipulates heart rate and systolic blood pressure. The effect of CPS stress on the stress hormone cortisol will also be correlated with memory for emotional material to see if an increase in cortisol level leads to enhanced memory for emotional material.

### *2.1.1 Hypotheses and predictions*

- 1) Post learning stress hormone activation (induced by CPS stress) will interact with the degree of arousal at initial encoding to enhance memory for emotionally arousing material.
- 2) Males and individuals with masculine personality types will have enhanced memory for central details of the arousing phase of the slide presentation
- 3) Females and individuals with feminine personality types will have enhanced memory for peripheral details of the arousing phase of the slide presentation.
- 4) The cortisol response, induced by CPS stress, will positively correlate with memory for emotional material

## **2.2 Experiment 1**

### **2.2.1 Methods**

#### *2.2.1.1 Participants*

The sample size chosen for this study was made on the basis of sample sizes used in previous research investigating the effects of various treatments on memory for emotional material (O' Carroll et al. 1999a & b; Papps et al. 2002). A power analysis calculation was also performed to help select an appropriate sample size. An effect size of .4 was entered into a power analysis software program (GPower™) in which alpha was set at .05 and power set at .80, and the number of groups at 2. This software program computed a sample size of approximately 50 participants as appropriate for this experiment, i.e. two groups of twenty five. Fifty participants (26 females and 24 males) from the student population were tested. There were 25 participants in the CPS group (12 Males and 13 females) and 25 participants in the control group (13 females and 12 males). Participants were recruited from the University population using monetary incentive. Only participants who were right handed, with no history of psychiatric illness, Reynauds disease and with English as their dominant language were recruited. Ethical approval to carryout this experiment was granted by the University of Stirling Psychology department ethics committee.

#### *2.2.1.2 Emotional stimulus*

The emotional stimulus employed in this study is an emotionally arousing slide presentation with an accompanying audio narrative (known as the Cahill slide presentation;

Cahill et al. 1995), depicting a story of a mother and her son going to visit their father at work, and while crossing a road the boy gets knocked down by a car. The presentation consists of 11 slides and the emotional content is introduced between slides 5 and 8 and includes an image of a boy's severed legs surgically reattached. For analysis purposes the slide presentation can be partitioned into an initial neutral phase (slides 1 to 4) with an emotionally arousing mid section (slides 5 to 8) followed by the conclusion to the story (slides 9 to 11). See Appendix 1 & 2.

### *2.2.1.3 Stress hormone activation*

After viewing the slide presentation participants are administered Cold Pressor Stress (CPS). This involves participants immersing their hand (up to the wrist) in ice cold water (0-3<sup>0</sup> C). Participants are instructed to keep their hand in the water for as long as they can but that they are free to remove it whenever they like. Participants are not allowed to keep their hand in the water for longer than 3 minutes for safety reasons. CPS reliably induces stress hormone activation, including cortisol activation (Lovallo 1975) and has been used to assess the effects on stress hormone activation on memory consolidation for emotional material by Cahill et al. (2003) and Andreano & Cahill (2005).

#### *2.2.1.4 Control condition*

Individuals in this condition were asked to submerge their hands (up to the wrist) in lukewarm water (37-40<sup>0</sup> C) for, one, two or three minutes. These times were randomly allocated to each participant using a random number generator found at [www.random.org](http://www.random.org). Cahill et al. (2003) employed this methodology so that participants in both control and CPS conditions were matched for length of time their hand was immersed in water.

#### *2.2.1.5 Blood pressure and heart rate recording*

Blood pressure and heart rate recordings were made using a Portapres<sup>TM</sup> non invasive blood pressure recording device. This device has shown to be a reliable and accurate tool in cardiovascular research (e.g. Schmidt, Wittenhaus, Steinmetz, Piccolo & Lupsen 1992; Young & Mathias 2004). This device consists of a main unit, a patient front-end box with finger cuff, and a height correction system. The main unit stores the analogue finger blood pressure waveform as well as beat-to-beat systolic, diastolic and mean arterial pressure, and heart rate. For the purpose of this study we are interested in recording heart rate and systolic pressure. Systolic pressure refers to the peak pressure in the arteries during the cardiac cycle. Diastolic pressure is the lowest pressure in the arteries during the cardiac cycle. Previous research has found that systolic blood pressure reacts more reliably in response to stress than diastolic blood pressure (e.g. Carroll, Ring, Hunt, Ford & Macintyre 2003). For this reason only participant's systolic blood pressure was analysed in the present experiment.

### *2.2.1.6 Memory testing*

Memory tests on the slide presentation consisted of a free recall and a recognition memory test. For the free recall test participants were instructed to try and recall as many details from the slide presentation as they could. They were instructed to try and recall the story line as well as any other details no matter how small. Responses were recorded onto a computer using Cool edit pro™ sound recording software ([www.syntrillium.com](http://www.syntrillium.com)). When participants could not remember any more details they were reminded that they were 11 slides in total and to repeat the exercise again so the experimenter could assess how many out of the 11 slides they could remember. The recognition memory test was given immediately after the free recall test. This test is a multiple choice test in which the participant is asked a question and given a choice of 4 answers. There are 5-9 questions per slide, the test begins with slide 1 and participants are informed when the experimenter is moving on to the next slide (see Appendix 3). Memory was tested at thirty minutes following viewing and again one week later. For the follow up memory test one week later, participants were contacted by phone and the same procedure as outlined above was followed. For this follow up memory test, participants' responses were recorded via a telephone conversation recorder.

### *2.2.1.7 Controlling for individual differences in memory for neutral material: the auditory verbal learning test (AVLT)*

The AVLT is a standard verbal memory test in psychological research (Rey 1964). The format of the AVLT consists of reading aloud a list of 15 words to the participant and then asking them to repeat back "as many words as they can remember". This procedure is repeated 5 times. Following this, an interference list of 15 words is read aloud (List B) and



the participant is asked to repeat back as many words as they can remember from that list. Immediately following this, participants are then asked to recall as many of the words from list A as they can; this trial is to determine the effects of interference on memory for the 'to be learned' material. Participants are also asked to recall words from list A 20 minutes following presentation of the list. Participants are then given a recognition memory test in which a list of 30 words are called out, including words from list A and list B, and they are asked if they recognize which list the words belong to. The AVLT yields a short delay memory score, a long delay memory score and a long delay recognition memory score. Both the long delay free recall and recognition memory scores were used as a measure of baseline memory for neutral material for participants in this study (see Appendix 4).

#### *2.2.1.8 Saliva sampling and cortisol analysis*

Saliva sampling involved participants depositing approximately 5 ml of saliva into a plastic tube. Five ml of saliva was required per saliva sample because the assay used to determine the level of cortisol in participants' saliva required at least 3 to 4ml of saliva in order for the results to be reliable. This methodology has been employed in previous research that investigated the effects of cortisol on facial appearance (Law Smith et al. 2005). Therefore 5ml was chosen to allow a safe 'buffer' as when transporting the saliva from site of sampling to the laboratory it was possible that approximately 1ml of saliva could deteriorate and be unsuitable for analysis. The first saliva sample took place during a 5 minute baseline period prior to viewing the slide presentation. Following CPS stress (or the control condition of immersing one's hand in lukewarm water), participants gave a second saliva sample. The third and final saliva sample was taken 20 minutes after CPS stress/control condition. Saliva was then frozen at -20°C until it was transported to a laboratory for analysis. Cortisol data were assayed by the biological sciences laboratory at

Queen Margaret University College, Edinburgh, using an 'in-house' enzyme linked immunosorbant assay (ELISA). The assay procedure was based on the indirect, competitive binding technique with samples first extracted using di-ethyl ether. Four mL of ether was added to 500µl of sample, vortex mixed for 10 minutes and then frozen at -80°C until the aqueous phase was frozen. The unfrozen ether was de-canted and evaporated with forced nitrogen. Samples were finally reconstituted with 500µl of assay buffer and vortex mixed prior to assay. Assay sensitivity was 0.5pg/mL; inter and intra-assay coefficients, obtained over 50 assay runs, were 6.8% and 2.7% respectively; cross reactivity with related compounds was minimal and the standard curve was highly reproducible ( $r=0.998$ ). Cross-reactivity with cortisone was 1.2%, cortisol 1.4%, Deoxy-cortisol 1%, testosterone 0.4% and other steroids < 0.5%. Intra and inter assay precision values were 3.2% and 5.7% respectively. The assay also involved an extraction step and recovery studies for a range of cortisol levels from 2.6-40.8 ng/mL were 91.8% to 106.7%. Assay sensitivity was 0.05 ng/mL.

#### *2.2.1.9 Masculine and feminine personality types*

The Bem sex role inventory (BSRI) independently assesses masculine and feminine personality traits in an individual (Bem 1981). The BSRI includes twenty items relating to feminine personality characteristics, twenty items relating to masculine personality characteristics and twenty items relating to personality characteristics of a gender neutral nature. Participants rate whether they possess each characteristic using a rating scale from one (never or almost never true) to seven (always or almost always true). For the purpose of this study those with a higher masculinity than a femininity score were deemed 'Bem males' and those with a higher femininity than a masculinity score were deemed 'Bem

females'. This method of categorising participants into 'Bem males' and 'Bem females' is outlined by Bem (1981). See Appendix 5 for BSRI.

#### *2.2.1.10 Big 5 personality dimensions*

Participants also completed the Big 5 personality questionnaire. The Big Five personality questionnaire is a classification of an individual's personality into five broad categories (or dimensions) of personality traits: neuroticism, extraversion, agreeableness, conscientiousness, and intelligence (Goldberg 1993). It was employed in this experiment to control for the effects of personality type on memory for emotional material. This study used a freeware version of the Big 5 located at the International Personality Item Pool website ([http://ipip.ori.org./ipip/new\\_home.htm](http://ipip.ori.org./ipip/new_home.htm)). See Appendix 6.

#### *2.2.1.11 Memory for central and peripheral details*

The recognition memory test yields a total of 74 responses which can be broken down into central and peripheral details. The criterion for determining which details of the slide presentation are peripheral and which are central were the same as employed by Cahill et al (2004): central details are any details that cannot be changed or removed without altering the fundamental elements of the story line. All other details are considered peripheral. This meant there were 56 peripheral details and 18 central details to be remembered. The central detail questions are presented in 'bold' font, and correct responses are underlined in Appendix 2.

### 2.2.1.12 Procedure

In order to control for the effects of diurnal variation in cortisol level testing took place in the afternoon at either 2pm or 4pm. Participants were randomly allocated to take part in the study at either 2pm or 4pm using a random number generator found at [www.random.org](http://www.random.org). Before participants viewed the slide presentation their baseline heart rate and systolic blood pressure was recorded using a Portapres<sup>TM</sup> blood pressure monitor. The baseline period lasted 5 minutes and during this time a saliva sample was taken in order to record baseline cortisol level. The blood pressure monitor continued recording for the duration of the slide presentation and until 5 minutes after the CPS/Control condition. Following Cahill et al. (2003), immediately after viewing the slide presentation participants were asked to rate how emotionally arousing they felt it was on a Likert scale of 1 (not at all emotionally arousing) to 10 (very emotionally arousing). Participants were then administered CPS stress or the control procedure, i.e. participants either submerged their hand up to the wrist in ice-cold (CPS) or lukewarm water (37-40 degrees Celsius) water. Participants knew before the study began that they would have to submerge their hands in either ice-cold or lukewarm water but they were not informed of which condition they were assigned to until immediately before hand immersion. Participants in the CPS condition were instructed to try and keep their hand in the water for as long as they could but that they were free to remove it whenever they wanted to and that they would not be allowed to keep it in for longer than three minutes. Participants assigned to the control condition were asked to remove their hand from the water at either 1, 2 or 3 minutes after immersion. This yielded an average of 2 minutes submersion time for control participants. Cahill et al. (2003) found that this procedure yielded similar hand immersion times for both CPS and control conditions. Following the CPS/control condition, participants rated how painful the experience was using a Likert scale of one (no pain or discomfort) to ten

(the most pain imaginable). Following the procedure outlined by Cahill et al. (2003), participants were given a towel to dry and/or warm their hand and were allowed rest for approximately one minute before a second saliva sample was then taken. Participants then completed the AVLT verbal memory test, followed by the Big 5 factor marker personality questionnaire and then the Bem sex role inventory (BSRI). Participants then completed the delayed free recall and recognition memory trials of the AVLT. The third and final saliva sample was then taken. Participants were then given two surprise memory tests on the slide presentation (the free recall followed by the recognition memory test). Participants were contacted by telephone one week later and were again given surprise free recall and recognition memory tests on the slide presentation. Participants' responses were recorded using a telephone conversation recorder.

#### *2.2.1.13 Statistical Analysis*

Whenever sphericity assumptions were violated in repeated measures analysis, Geisser-Greenhouse correction was employed. All analyses were performed using SPSS™ (ed) 13.

##### *2.2.1.13.1 Analysis of Baseline variables*

A One way ANOVA was performed on the potentially confounding variables (see Table 2.1) to determine if there was any difference between Control Females, CPS Females, Control Males, and CPS Males for these variables. The potentially confounding variables are as follows: age, baseline systolic blood pressure, baseline diastolic blood pressure, baseline heart rate, baseline cortisol (ng/ml), AVLT delay free recall, AVLT long delay, emotional arousal to slide presentation, and the Big 5 personality dimensions of:

Extraversion, Agreeableness Conscientiousness, Emotional Stability and Intelligence.

Bonferroni adjustment was employed to correct for multiple comparisons.

#### *2.2.1.13.2. Analysis of memory performance*

This study is primarily interested in testing the hypothesis that the degree of arousal at initial encoding interacts with post learning stress hormone activation to enhance memory for emotional material. Therefore, following the established protocol (Cahill et al. 1995; Cahill et al. 2004), memory performance on the slide presentation was partitioned into 3 discrete phases: an initial Neutral phase, a second Emotional phase, and a third Concluding phase. The initial Neutral phase consists of the responses to questions pertaining to slides 1 to 4 of the slide presentation. The Emotional phase consists of responses to questions pertaining to slides 5 to 8 of the presentation. The Concluding phase consists of responses to questions pertaining to slides 9 to 11 of the slide presentation. Repeated measures analysis was performed to look for a 'Slide Phase' (i.e. Neutral/Emotional/Concluding) \* 'Stress Condition' (i.e. CPS group/Control group) interaction for memory performance. Memory performance the Emotional phase of the presentation was also examined separately using one way ANOVA. Cahill et al. (2004) also employed a 'difference score'; i.e. the difference in memory performance between the Emotional phase and the initial Neutral phase to investigate emotions effect on memory. This study will also employ this analysis to investigate whether there is a differential effect of post learning CPS, as opposed to the control condition, on memory for emotional material.

#### 2.2.1.13.3 *Analysis of sex related personality traits and memory performance*

This study is also investigating 'sex' (and 'Bem sex') differences in memory for peripheral and central details of emotional material. Total memory scores for peripheral and central details were compared between males and females and between 'Bem males' and 'Bem females'. The interaction of 'Slide Phase' with 'sex' (and 'Bem sex') on memory scores was also investigated. The effects of post learning CPS on memory for central and peripheral details was also analysed.

#### 2.2.1.13.4 *Analysis of cardiac variables*

A repeated measures ANOVA, with 'Stress condition' (i.e. the CPS/Control condition) as the between subjects factor and 'Experimental Phase' the within subjects factor, was employed to analyse how heart rate and systolic blood pressure changed during the course of the experiment. Therefore, a 2 (Stress Condition group: CPS stress, Control condition) \* 6 (Experimental Phase: 1<sup>st</sup> Baseline phase, Neutral phase of slide presentation, Emotional phase of slide presentation, Concluding phase of slide presentation, CPS/Control phase, 2<sup>nd</sup> Baseline phase) design was implemented to investigate how CPS stress and the emotionally arousing slide presentation affected heart rate and systolic blood pressure.

#### 2.2.1.13.5 *Analysis of cortisol data*

In order to investigate whether CPS stress induced a stress hormone response, the difference in rise of cortisol level between the CPS and control groups was also analysed. Also, rise in cortisol level was correlated with memory performance of emotional material,

in order to investigate if an increase in cortisol level, due to post-learning stress hormone activation, leads to enhanced memory of emotional material.

## **2.2.2 Results**

### *2.2.2.1 Potentially confounding variables.*

A one way ANOVA (corrected for multiple comparisons) revealed significant differences between the experimental groups on the personality dimensions of ‘agreeableness’ and ‘emotional stability’ (see Table 2.1). Bonferroni comparisons revealed that female Controls were significantly higher than male Controls on ‘agreeableness’ [ $p=.017$ ], and the female CPS group were significantly lower in emotional stability than the male Control group [ $p=.017$ ]. Before proceeding with analysis of memory data ‘agreeableness’ and ‘emotional stability’ were correlated with ‘total’ free recall and recognition memory, and free recall and recognition memory for the Emotional phase of the slide presentation. ‘Agreeableness did not correlate with ‘total’ free recall memory [ $r = -.065$ ,  $N=46$ ,  $p=.667$ ], ‘total’ recognition memory [ $r = -.138$ ,  $N=47$ ,  $p=.355$ ], Emotional phase free recall [ $r = -.22$ ,  $N=46$ ,  $p=.143$ ] or recognition memory [ $r = -.191$ ,  $N=47$ ,  $p=.198$ ]. Therefore, differences in ‘agreeableness’ and ‘emotional stability’ between groups was not considered a source of confound.

### *Internal Reliability*

Cronbach’s Alpha was employed to test the internal reliability of the five personality dimensions of the Big 5 questionnaire. For Agreeableness  $\alpha = .8$ , For Extraversion  $\alpha = .85$ , for Conscientiousness  $\alpha = .81$ , for Emotional stability  $\alpha = .84$ , for Intelligence  $\alpha = .86$ .



**Table 2.1.** Comparison of four participant groups on potentially confounding variables

	Female control N=13	SD	Female CPS N=13	SD	Male Control N=12	SD	Male CPS N=12	SD	F	P
Age	23.58	5.64	22.17	2.79	24.44	4.72	22.44	3.05	0.65	0.59
Baseline systolic BP	131.96	17.52	126.04	15.44	125.26	13.48	125.9	10.93	0.53	0.67
Baseline diastolic BP	73.21	10.02	70.20	6.78	71.84	12.17	71.36	7.22	0.21	0.89
Baseline HR	78.99	9.25	81.54	12.45	78.00	9.65	79.33	9.03	0.25	0.86
Baseline cortisol ng/ml	7.48	2.58	7.30	3.43	8.67	3.15	6.87	2.76	0.79	0.50
AVLT Delay free recall	10.92	1.98	12.17	2.55	11.91	1.87	10.33	2.23	1.83	0.16
AVLT long Delay	14.31	1.38	13.83	1.53	13.83	1.40	14.00	1.13	0.34	0.80
Emotional arousal to SP	5.85	1.21	6	1.92	4.5	1.68	4.67	2.02	2.54	0.07
Ex	5.08	6.51	3.92	9.91	8.55	5.26	4.00	6.42	1.01	0.40
Ag	20.85	2.76	18.92	4.17	15.18	4.56	16.33	5.66	4.10	0.01
Con	10.62	6.54	14.75	2.90	10.55	7.81	10.25	7.01	1.38	0.26
ES	-17.69	4.82	-19.83	6.52	-10.64	8.30	-16.08	7.91	3.65	0.02
In	17.38	4.87	18.25	9.55	21.55	5.96	19.33	7.08	0.76	0.52

**Key:** **SD:** standard deviation, **bp:** blood pressure, **AVLT:** auditory verbal learning test, **SP:** slide presentation, **HR:** heart rate, **Ex:** extraversion, **Ag:** agreeableness, **Con:** conscientiousness, **ES:** emotional stability, **In:** intelligence.

### *2.2.2.2 The effect of CPS stress and the slide presentation on Cardiac variables & Cortisol in Experiment 1*

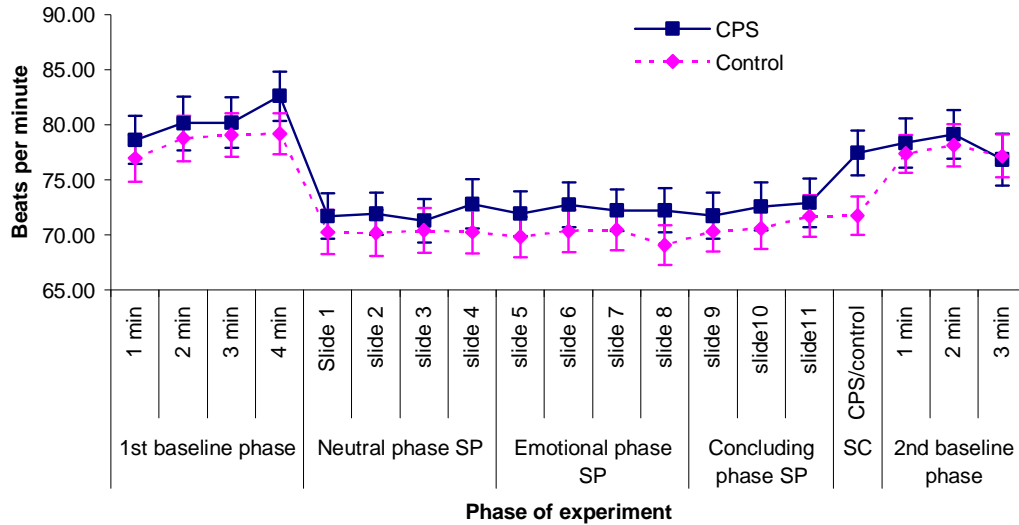
*Note: during the '1<sup>st</sup> Baseline phase' the first saliva sample was taken from participants in order to measure baseline cortisol level. During the '2<sup>nd</sup> Baseline phase' the second saliva sample was taken from participants in order to investigate how cortisol level had changed in response to the CPS stress or the control condition..*

#### *2.2.2.2.1 Heart rate Experiment 1*

A repeated measures ANOVA with 'Stress Condition' (CPS/Control condition) as the between subject factor and 'Experimental Phase' ('1<sup>st</sup> Baseline phase', 'Neutral phase of slide presentation', 'Emotional phase of slide presentation', 'Concluding phase of slide presentation', CPS/control phase, and '2<sup>nd</sup> Baseline phase') as the within subjects factor revealed a within subjects effect of 'Experimental Phase' on heart rate [ $F(3.5, 1.34.6)=65.06, p<.001$ ]. Bonferroni pairwise comparisons revealed that the 1<sup>st</sup> and 2<sup>nd</sup> Baseline phases had higher heart rate than any of the other 4 experimental phases [all  $p<.001$ ]. The 2<sup>nd</sup> Baseline phase showed higher heart rate than the 1<sup>st</sup> Baseline phase [ $p=.006$ ]. The 3 phases of the slide presentation did not differ from each other [all  $p=1$ ]. There was no main effect of 'Stress Condition' on heart rate [ $F(1,40)=.578, p=.451$ ]. The repeated measures analysis revealed an 'Experimental Phase' \* 'Stress Condition' interaction [ $F(3.5, 139.97)=3.139, p=.021$ ]. Further analysis revealed the interaction was due to the CPS group having significantly elevated heart rate during the 'CPS/Control phase' than controls as demonstrated by a one way ANOVA [ $F(1,44)=4.562, p=.039$ ]. See Figure 2.1.

**Figure 2.1** Heart rate for Control and CPS groups during the course of Experiment 1.

Error bars represent +1/-1 standard error of the mean.



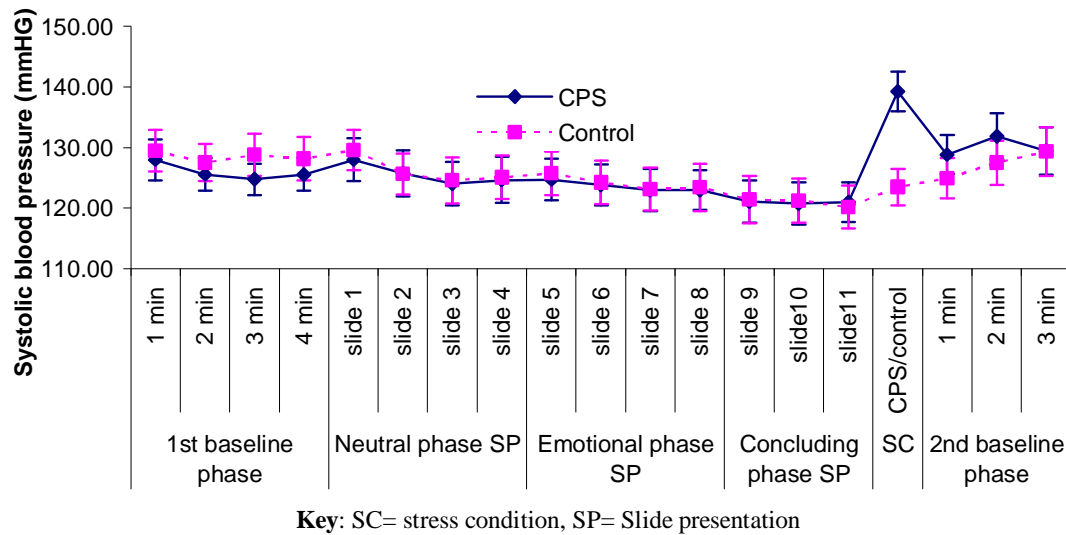
**Key:** SC= stress condition, SP= Slide presentation

#### 2.2.2.2.2 Systolic pressure Experiment 1

A repeated measures ANOVA with ‘Stress Condition’ (CPS/Control condition) as the between subject factor and ‘Experimental Phase’ (‘1<sup>st</sup> Baseline phase’, ‘Neutral phase of slide presentation’, ‘Emotional phase of slide presentation’, ‘Concluding phase of slide presentation’, ‘CPS/control phase’, and ‘2<sup>nd</sup> Baseline phase’) as the within subjects factor revealed a within subjects effect of ‘Experimental Phase’ on systolic pressure [F(5,185)=14.35 , p<.001]. Bonferroni pairwise comparisons revealed that the Concluding phase of the slide presentation had lower systolic pressure any of the other experimental phases [all p<.006]. The 2<sup>nd</sup> Baseline phase had higher systolic pressure than both the Concluding phase and the Emotional phase of the slide presentation [p=.007] and [p<.001]. There were no other ‘Experimental Phase’ differences in systolic blood pressure [all p>.51,

<1]. Repeated measures analysis revealed no main effect of ‘Stress Condition’ on systolic blood pressure [ $F(1,39)=.281, p=.599$ ]. There was, however, an ‘Experimental Phase’ \* ‘Stress Condition’ interaction [ $F(2.8, 110.4)=13.595, p=.0001$ ] on systolic pressure. Further analysis revealed the interaction was due to systolic pressure being significantly elevated in the ‘CPS group’ in comparison to the ‘Control group’ during the ‘CPS/Control phase’ of the experiment, as demonstrated by a one way ANOVA [ $F(1,45)=12.626, p=.001$ ]. See Figure 2.2.

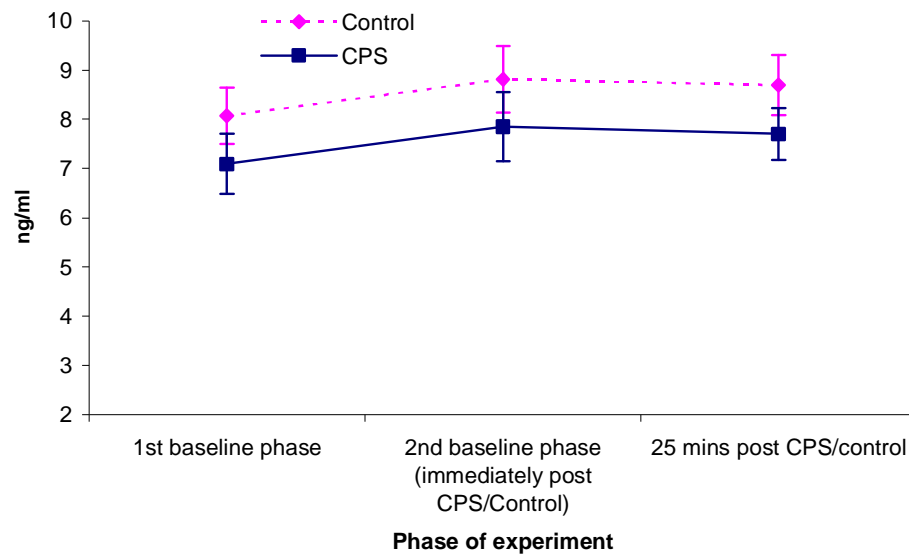
**Figure 2.2** Systolic pressure for Control and CPS groups during the course of Experiment 1. Error bars represent +1/-1 standard error of the mean.



### 2.2.2.2.3 Salivary cortisol Experiment 1

A repeated measures ANOVA with ‘Stress Condition’ (CPS/Control groups) as the between subject factor; and ‘Experimental Phase’ (‘Baseline cortisol’, ‘Cortisol immediately post CPS/Control phase’ and ‘Cortisol 25 minutes post CPS/Control phase’) as the within subjects factor revealed a main effect of ‘Experimental Phase’ on cortisol level [ $F(1.7, 76.29) = 3.33, p = .04$ ]. Bonferroni pairwise comparisons revealed this main effect was due to higher cortisol level for ‘Cortisol 25 minutes post CPS/Control phase’ than ‘Baseline cortisol’ [ $p = .02$ ]. There was no ‘Stress Condition’ \* ‘Experimental Phase’ interaction on cortisol levels [ $F(6, 76.3) = .025, p = .96$ ]. There was also no main effect of ‘Stress Condition’ on cortisol levels [ $F(1,47) = 1.65, p = .205$ ].

**Figure 2.3** Change in salivary cortisol during course of Experiment 1. Error bars represent  $\pm 1$  standard error of the mean.



### *2.2.2.3 Memory for slide presentation Experiment 1.*

#### *2.2.2.3.1 Recognition memory one week later*

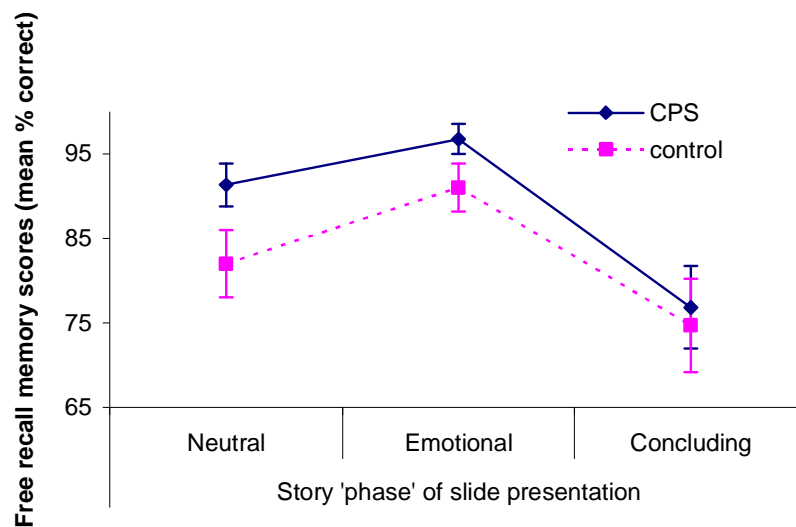
Analysis of responses from the free recall and recognition memory tests administered to participants one week after presentation of the slide presentation yielded surprising results. Participants showed enhanced memory on the free recall test of the slides (1 to 11) when tested one week later [mean=94.54%, standard deviation (SD) = 10%] than when they were tested 30 minutes after slide presentation [mean=86.9%, SD=11.81%] [ $t(42) = -4.336, p = .0001$ ]. The pattern of responses on the recognition memory test one week later closely mapped responses of the initial recognition memory test. It was clear that participants improved memory on the free recall (one week later) was due to questions on the initial recognition memory test 'informing' them of certain events that took place in the slide presentation. It also seemed apparent that for the 2<sup>nd</sup> recognition memory test (1 week later) participants were simply remembering responses they gave to the initial recognition memory test rather than actually trying to remember the actual slide presentation itself. A similar effect of repeated testing on memory for emotional material has also been reported by Burke, Heuer and Reisberg (1992). For the reasons outlined above memory scores from the follow up memory tests one week later were not included in the results section.

#### *2.2.2.3.2 Free recall memory Experiment 1*

Repeated measures ANOVA with 'Stress Condition' (i.e. CPS/Control) as the between subject factor and 'Slide Phase' (Neutral/Emotional/Concluding) as the within subject factor revealed a significant effect of 'Slide Phase' on free recall memory [ $F(1.7, 77.98) = 14.337, p < .001$ ]. Bonferroni pairwise comparison revealed significantly greater

memory for the ‘Emotional Phase’ in comparison to the ‘Neutral phase’ [ $p=.023$ ] and the ‘Concluding Phase’ [ $p=.0001$ ]. Crucially, no ‘Slide Phase’ \* ‘Stress Condition’ interaction on memory performance was found [ $F(5.05, 77.98)=.551, p=.578$ ]. There was also no main effect of ‘Stress Condition’ on memory scores [ $F(1,46)=2.26, p=.14$ ]. Memory scores for the Neutral phase were subtracted from the Emotional phase to yield a ‘difference score’. A one way ANOVA revealed no difference in the ‘difference score’ between the CPS and control groups [ $F(1,46)=.473, p=.495$ ] (see Figure 2.4).

**Figure 2.4** Free recall memory for slide presentation. Error bars represent  $\pm 1$  standard error of the mean.

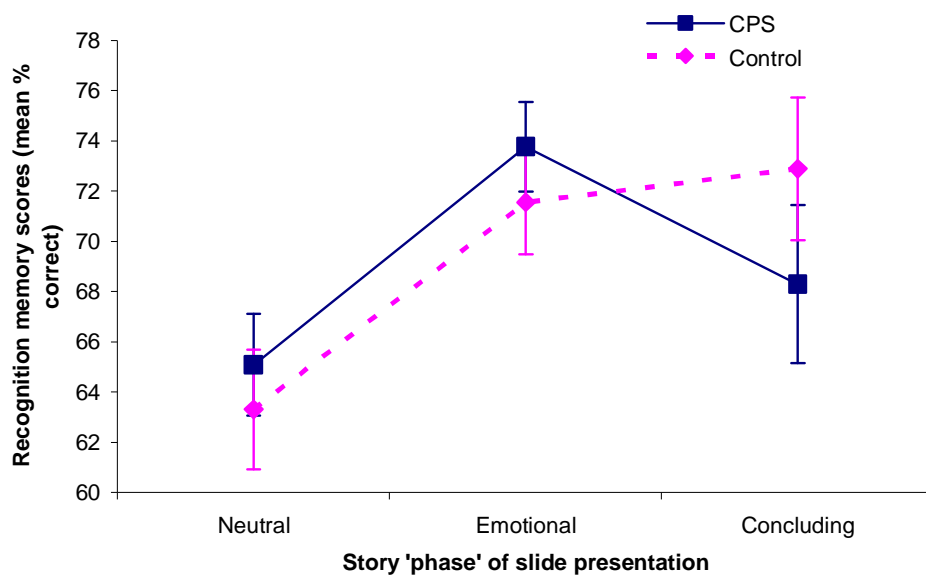


### 2.2.2.3.3 Recognition memory Experiment 1

Repeated measures ANOVA with ‘Stress Condition’ (i.e. CPS/Control) as the between subject factor and ‘Slide Phase’ (Neutral/Emotional/Concluding) as the within subject factor revealed a significant effect of ‘Slide Phase’ on recognition memory [ $F(2,94)=11.396, p=.0001$ ]. Bonferroni pairwise comparisons revealed significantly greater memory for the ‘Emotional phase’ than both the ‘Neutral phase’ and the

'Concluding phase' [all  $p < .004$ ]. There was no main effect of 'Stress Condition' on recognition memory performance [ $F(1,47) = .006$ ,  $p = .939$ ]. Crucially, there was no 'Slide Phase' \* 'Stress Condition' interaction on recognition memory performance [ $F(2,94) = .208$ ,  $p = .131$ ]. Recognition memory scores from the 'Neutral phase' were subtracted from the 'Emotional phase' to yield a difference score. A one way ANOVA revealed no difference in 'difference score' between the CPS and control groups [ $F(1,47) = .02$ ,  $p = .889$ ]. See Figure 2.5.

**Figure 2.5** Recognition memory for slide presentation Experiment 1. Error bars represent  $\pm 1$  standard error of the mean.





#### 2.2.2.3.4. *Cortisol and memory performance Experiment 1.*

Neither the CPS or control groups showed any difference in rise in cortisol level during this study (see Figure 2.3), therefore 'rise in cortisol' levels for both CPS and control groups was amalgamated in order to examine whether 'rise in cortisol' was correlated with memory performance. Rise in cortisol level between the '1<sup>st</sup> Baseline phase' and the '2<sup>nd</sup> Baseline phase' (immediately post CPS/control) was correlated with 'total free recall memory' [ $r(1,47)=-.051, p=.732$ ], free recall for the Emotional phase [ $r(47)=.127, p=.395$ ], 'total recognition memory' performance [ $r(47)=-.116, p=.433$ ], and recognition memory performance for the Emotional phase [ $r(47)=-.037, p=.804$ ], all analyses yielded non-significant findings. Rise in cortisol between the '1<sup>st</sup> Baseline phase' and '25 minutes post CPS/control' was then correlated with the same variables: 'total free recall memory' [ $r(48)=.04, p=.785$ ], 'free recall for the Emotional phase' [ $r(48)=.142, p=.337$ ], 'total recognition memory' [ $r(48)=-.084, p=.568$ ], 'recognition memory for the Emotional phase' [ $r(48)=-.009, p=.951$ ]. Again these analyses yielded non-significant findings.

#### 2.2.3.5 *Relationship between memory performance for slide presentation and subjective discomfort of CPS stress Experiment 1*

A one way ANOVA revealed that participants that experienced CPS stress rated the experience as more painful than participants that experienced the control condition [ $F(1,48)=101.29, p<.001$ ]. The mean rating for participants in the CPS group was 4.72 (SD=1.6), compared to a rating of 1.32 (SD=.56) for controls. However, for CPS group participants 'pain ratings' did not correlate with either free recall or recognition memory performance for any of the 3 phases of the slide presentation or for total free recall, and total recognition memory scores (i.e. all phases added together) [all  $p>.40 <.91$ ].

#### 2.2.2.3.6 *The effect of 'sex' and 'Bem sex' on memory for central and peripheral details*

##### *Experiment 1*

Analysis of memory scores revealed no significant findings concerning sex differences in memory scores for emotional material. The analysis revealed, a) no sex differences in memory for central and peripheral details, b) no differences between 'Bem males' and 'Bem females' in memory performance for central and peripheral details. In order to keep the presentation of the results for this Chapter as concise and clear as possible, the analyses and graphs of these findings are presented in Appendix 7.

#### **2.2.4 Discussion**

Analysis of cardiac variables indicates that the CPS condition induced an increase in heart rate and systolic pressure relative to the control condition. These results indicate CPS stress is a reliable physiological stress inducer. However, unlike previous research (e.g. Lovallo 1975) CPS stress did *not* show a differential rise in cortisol level compared to the control condition. One would expect that an increase in physiological arousal would stimulate an increase in stress hormone activation. A possible reason for this will be discussed below. Heart rate did not vary by slide phase. However, systolic pressure showed a significant decrease as the slide presentation progressed. However, this variation did not indicate that the emotionally arousing phase was responsible for the change in systolic pressure; instead there was a general decrease in systolic blood pressure from the beginning of the slide presentation to the end. Therefore this finding does not suggest that the emotional stimulus effectively manipulated cardiac variables in the expected manner.

The hypothesis that 'post learning stress hormone activation interacts with the degree of arousal at initial encoding to enhance memory for emotional material' was not supported by results of the analysis of both free recall and recognition memory scores. Post learning stress hormone activation did not enhance memory for the emotionally arousing phase of the presentation. Change in cortisol level between the 1<sup>st</sup> baseline phase and a) the '2<sup>nd</sup> Baseline phase (immediately post CPS/Control condition) and b)'25 minutes post CPS' did not correlate with memory of emotional material. The results of this experiment are in conflict with two previous studies that have investigated the effects of post learning endogenous stress hormone activation on memory consolidation of emotional material. For example, Nielson, Radtke & Jensen (1996) induced physiological arousal in participants by asking them to increase muscle tension (using a hand dynamometer) in order to see how physiological arousal might affect memory consolidation of a list of highly imageable nouns. The authors reported that arousal induced shortly after learning did enhance memory consolidation for the words. They also oppose those of Cahill et al. (2003) who found an enhancing effect of post learning stress hormone activation via CPS stress on memory consolidation of emotional material, and also those of Andreano & Cahill (2005) who found a similar effect of CPS stress on memory consolidation for neutral material. However, these results are congruent with those of Libkuman, Nichols-Whitenead, Griffith & Thomas (1999) who found that physiological arousal (induced by running energetically on a treadmill) while viewing an emotionally arousing slide presentation also failed to enhance memory consolidation for emotional material.

Additionally, males (and 'Bem males') did not show enhanced memory for central details of the emotionally arousing phase of the slide presentation. Females (and 'Bem females') did not have enhanced memory for peripheral details of the emotional phase of the slide presentation. Post learning stress also did not affect memory for central and peripheral

details for both males and females, or for ‘Bem males’ and ‘Bem females’. Again these results are in contrast to those of Cahill et al. (2004) who found that ‘Bem males’ had enhanced memory for central details for the ‘Emotional phase of the slide presentation.

However, a crucial aspect of this study is that heart rate data show that participants seem just as physiologically aroused during both the 1<sup>st</sup> and 2<sup>nd</sup> Baseline phases as they were during the CPS condition, e.g. see Figure 2.1. This figure illustrates how heart rate for the control participants as they are giving their 2<sup>nd</sup> saliva sample (i.e. the 2<sup>nd</sup> Baseline phase), is equivalent to the heart rate of CPS participants when they had their hand immersed in ice cold water. This suggests that the saliva sampling (which occurred during these phases) may have inadvertently induced physiological stress in participants. Also, both the control and CPS groups showed a significant rise in cortisol between the ‘1<sup>st</sup> Baseline phase’ and the ‘2<sup>nd</sup> Baseline phase’. This finding suggests that physiological stress, inadvertently induced by saliva sampling, may have masked the effects of CPS stress hormone activation on memory consolidation of emotional material. The process of saliva sampling involved participants having to deposit 5ml of saliva into a plastic tube, in the presence of the experimenter. Most saliva sampling techniques require a fraction of the 5ml of saliva that was required in this study. The reason 5ml was chosen for this study was due to the requirements of the assay technique that was performed on the saliva. It is reasonable to assume that producing this amount of saliva, and depositing it into a clear plastic tube in the presence of an experimenter, may have been socially stressful for participants. Experimenter observations suggest this was the case, with many participants clearly blushing and emanating uncomfortable body language. Thus, stress induced by saliva sampling may have inadvertently masked the effects of CPS stress on memory consolidation of emotional material. Therefore, a replication of this study *without saliva*

*sampling*, so as to reduce the possible masking effects of an inadvertent stressor, was deemed necessary.

## **2.3 Experiment 2**

### **2.3.1 Introduction**

This second experiment again aimed to investigate the effects of post learning CPS stress on memory consolidation for emotional material. It also aimed to investigate the effects of 'sex' and 'Bem sex' on memory for central and peripheral details of emotional material and how post learning CPS stress interacts with these variables. Due to the possible stress inducing effects of saliva sampling in the first experiment, saliva sampling and thus cortisol analysis was excluded from this second experiment. This modification to the initial experiment was made on the basis that saliva sampling may have inadvertently acted as a psychological stressor, thus masking the effects of CPS stress on memory for emotional material. Instead of taking a saliva sample from participants during the two baseline phases, participants instead completed the Spielberger State and Trait anxiety questionnaires and also a simple demographics sheet. A second modification to Experiment 2 was that participants were only given one memory test; one week after viewing the slide presentation. In Experiment 1, the pattern of responses on the recognition memory test one week later closely mapped responses of the initial recognition memory test. It was clear that participants' improved memory on the free recall test (one week later) was due to questions on the initial recognition memory test 'informing' them of certain events that took place in the slide presentation. It also seemed apparent that for the 2<sup>nd</sup> recognition memory test (1 week later) participants were simply remembering responses they gave to the initial recognition memory test rather than actually trying to

remember the actual slide presentation itself. As with the previous Experiment the follow up memory tests would be performed by contacting the participants by telephone.

Experiment 2 would also measure the same cardiac variables as the previous study and compare cardiac variables of Experiment 1 with cardiac variables of Experiment 2 to investigate whether saliva sampling did inadvertently act as a stressor in Experiment 1.

Experiment 2 is also interested in how the emotionally arousing slide presentation and CPS stress affect heart rate and systolic blood pressure.

## **2.3.2 Methods**

### *2.3.2.1 Participants*

The sample size chosen for Experiment 2 was increased in relation to Experiment 1 to protect against the possibility that participants would not be contactable for the 2<sup>nd</sup> session of the experiment one week later. Sixty-nine (33 females, 36 males) students from the University of Stirling student population were recruited (using £5 as monetary incentive) and took part in initial testing. Fourteen Participants (9 males, 5 females) could not be contacted by telephone for the memory tests one week later. One individual thought their memory would be tested during the second telephone session and thus their scores were excluded from analysis. Therefore, there were 54 individuals (27 males: 13 Control, 14 CPS; 27 females: 14 Controls, 13 CPS) whose memory scores were included in analysis. Participants were recruited using the same criteria as the first experiment.

### *2.3.2.2 Materials*

The materials used in this 2<sup>nd</sup> experiment were identical to those used in the first, with the addition of the Spielberger State and Trait anxiety questionnaires (STAI) (Spielberger 1983), which participants were asked to complete during the 1<sup>st</sup> Baseline phase (i.e. when their baseline heart rate and systolic blood pressure was being recorded) instead of saliva sampling. The State anxiety questionnaire allows one to establish the temporary condition of 'state' anxiety, whereas the trait anxiety questionnaire enables one to gauge the more long-term condition of 'trait' anxiety. See Appendices 8 and 9.

### *2.3.2.3 Modifications to procedure*

The procedure was identical to that of the initial experiment with some minor modifications. Participants completed the Spielberger State and Trait anxiety questionnaires during the '1<sup>st</sup> Baseline phase'. Due to the potential psychological stress caused by saliva sampling in Experiment 1, saliva sampling was excluded from Experiment 2. As Experiment 2 was concerned about avoiding inadvertently stressing participants, it was decided to give participants a modified abbreviated version of the AVL T to reduce the possible stress this test could potentially cause participants.

Participants were given 3 trials in which list A was read aloud to them, rather than 5. This modification was made to make the test less mentally taxing for participants. Also participants were explicitly informed that that list A would be read aloud to them 3 times. This modification was made to ensure participants would not worry that the experimenter would continue asking them to repeat back the List A words until they were successful in recalling all 15 words in one trial. Such a worry may have caused some participants to feel psychologically stressed in Experiment 1. There was also no free recall memory test on

the slide presentation 30 minutes after presentation, and no recognition memory test on the slide presentation 40 minutes after presentation. Instead both memory tests were given one week later when participants were contacted by telephone and administered both memory tests over the phone. Participants' responses were recorded using a telephone conversation recorder, as in Experiment 1.

#### *2.3.2.4 .Additional analysis*

As results from Experiment 1 suggested that saliva sampling may have inadvertently acted as a stressor, this experiment also aimed to investigate this further by comparing cardiac variables from Experiment 1 with Experiment 2 and using repeated measures ANOVA to determine whether an 'Experiment' (Experiment 1/Experiment 2) \* 'Experimental Phase' ('1<sup>st</sup> Baseline phase', 'Slide presentation', '2<sup>nd</sup> Baseline phase') interaction, which may indicate that saliva sampling did inadvertently elevate cardiac variables in Experiment 1.

### **2.3.3 Results**

#### *2.3.3.1 Potentially confounding variables*

A one way ANOVA (corrected for multiple comparisons) revealed no differences between experimental groups on potentially confounding variables (see Table 2.2). Reliability: Cronbach's Alpha was used to determine the internal reliability of both State and Trait anxiety questionnaires and the Big 5 personality dimensions. For State anxiety  $\alpha = .84$ ; for Trait anxiety  $\alpha = .87$ ; .for Agreeableness  $\alpha = .77$ , For Extraversion  $\alpha = .81$ , for Conscientiousness  $\alpha = .76$ , for Emotional stability  $\alpha = .83$ , for Intelligence  $\alpha = .81$ .



**Table 2.2 Potentially confounding variables Experiment**

	<b>Male Control N=13</b>	<b>Male CPS N=14</b>	<b>Female Control N=14</b>	<b>Female CPS N=13</b>	<b>F</b>	<b>P</b>
Age	22.47 (6.35)	24.25 (5.99)	21.07 (3.22)	25.77 (6.97)	1.72	0.18
Baseline systolic BP	113.31 (15.6)	110.89 (7.82)	120.39 (14.67)	119.22 (13.91)	0.77	0.52
Baseline diastolic BP	68.56 (14.83)	67.04 (6.59)	66.91 (8.01)	73.73 (15.41)	0.77	0.52
Baseline HR	80.68 (14.87)	75.55 (12.17)	81.00 (9.8)	77.24 (10.02)	0.47	0.70
AVLT short Delay free recall	9.54 (2.44)	9.00 (2.27)	9.50 (3.17)	11.20 (2.53)	1.47	0.24
Emotional arousal to SP	5.40 (1.84)	5.76 (2.82)	6.13 (1.64)	4.47 (1.64)	1.80	0.16
Ex	4.50 (6.46)	3.06 (6.45)	5.07 (9.35)	2.59 (8.22)	0.37	0.77
Ag	15.81 (13.18)	12.44 (8.39)	18.50 (6.69)	14.59 (8.07)	1.13	0.34
Con	3.56 (5.38)	6.50 (7.11)	8.50 (6.01)	5.29 (6.27)	1.66	0.19
ES	-5.63 (6.02)	-7.89 (6.36)	-8.43 (5.67)	-8.06 (5.52)	0.73	0.54
In	14.94 (9.98)	15.44 (9.32)	18.71 (7.67)	15.12 (8.4)	0.58	0.63
State anxiety	1.54 (9.68)	4.00 (9.69)	1.07 (10.32)	7.00 (8.82)	0.46	0.71
Trait anxiety	-14.71 (10.63)	-11.39 (9.92)	-14.69 (10.85)	-12.13 (10.68)	1.05	0.38
<b>Key:</b> SD: standard deviation, BP: blood pressure, AVLT: auditory verbal learning test, SP: slide presentation, Ex: extraversion, Ag: agreeableness, Con: conscientiousness, ES: emotional stability, In: intelligence. Standard deviation in parentheses.						

*2.3.3.2 The effect of CPS stress & the slide presentation on cardiac variables for Experiment 2*

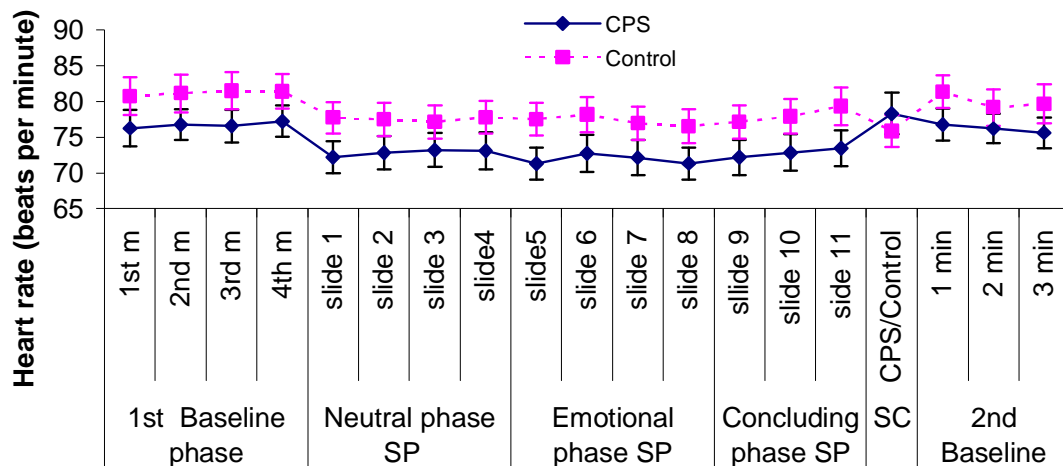
*2.3.3.2.1 Heart Rate Experiment 2*

A repeated measures ANOVA with ‘Stress Condition’ (CPS/Control condition) as the between subject factor and ‘Experimental Phase’ (‘1<sup>st</sup> Baseline phase’, ‘Neutral phase of

slide presentation', 'Emotional phase of slide presentation', 'Concluding phase of slide presentation', 'CPS/control phase', and '2<sup>nd</sup> Baseline phase') as the within subjects factor revealed a within subjects effect of 'Experimental Phase' on heart rate [ $F(2.6, 85.6)=6.34$ ,  $p=.001$ ]. Bonferroni pairwise comparisons revealed this main effect was due to enhanced heart rate for the '1<sup>st</sup> Baseline phase' compared to the 3 phases of the slide presentation [all  $p<.003$ ,  $>.001$ ]. There was no main effect of 'Stress Condition' on heart rate [ $F(1, 33)=.001$ ,  $p=.981$ ]. There was, however, an 'Experimental Phase' \* 'Stress Condition' (CPS/control groups) interaction [ $F(2.6, 85.6)=3.744$ ,  $p=.018$ ] on heart rate. Looking at Figure 2.6, one can deduce that the interaction was due to heart rate for the CPS group increasing during the 'CPS/Control phase', while heart rate for the Control group decreased during the 'CPS/Control phase'. See Figure 2.6.

**Figure 2.6** Heart rate for Control and CPS groups during the course of Experiment 2.

Error bars represent +1/-1 standard error of the mean.

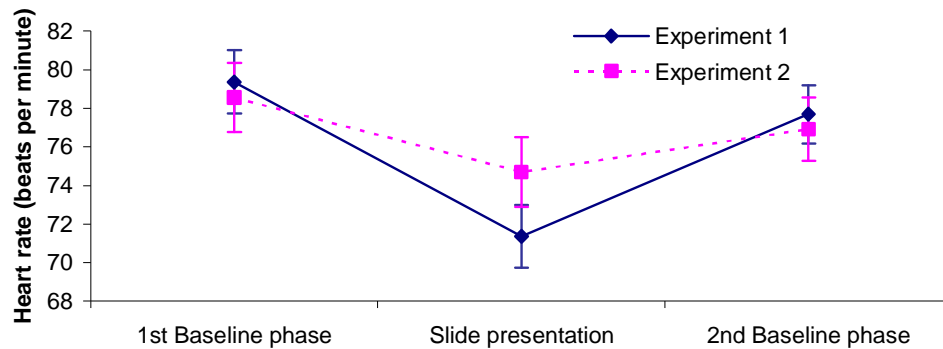


**Key:** SC= stress condition, SP= Slide presentation

### 2.3.3.2.2 Heart rate: Experiment 1 versus Experiment 2

Data from both the CPS and Control groups from both Experiment 1 and 2 was included in this analysis. In order to determine whether saliva sampling in Experiment 1 acted as a stressor and elevated heart rate level inadvertently, a repeated measures ANOVA was performed with 'Experiment' (Experiment 1/ Experiment 2) as the between subjects factor and 'Experimental Phase' (1<sup>st</sup> Baseline phase, 'Slide Presentation', '2<sup>nd</sup> Baseline phase') as the within subject factor, revealing an 'Experiment' \* 'Experimental Phase' interaction on heart rate [ $F(2,150)= 13.763, p<.001$ ]. This interaction was due to lower heart rate for the 1<sup>st</sup> & 2<sup>nd</sup> Baseline phases in Experiment 2 than Experiment 1 but higher heart rate for the 'Slide presentation phase' in Experiment 2 than Experiment 1. There was also no main effect of 'Experiment' on heart rate [ $F(1, 75)=.065, p=.8$ ] (see Figure 2.7).

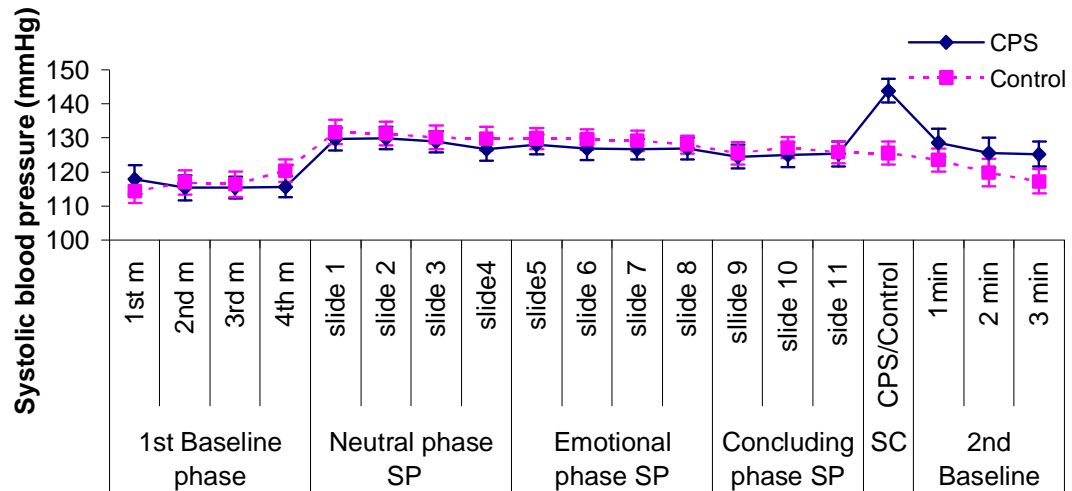
**Figure 2.7** Heart rate: Comparing Experiments 1 & 2. Error bars represent +1/-1 standard error of the mean.



### 2.3.3.2.3 .Systolic blood pressure Experiment 2

A repeated measures ANOVA with 'Stress Condition' (CPS/Control condition) as the between subject factor and 'Experimental Phase' ('1<sup>st</sup> Baseline phase', 'Neutral phase of slide presentation', 'Emotional phase of slide presentation', 'Concluding phase of slide presentation', 'CPS/control phase', and '2<sup>nd</sup> Baseline phase') as the within subjects factor revealed a within subjects effect of 'Experimental Phase' on systolic blood pressure [ $F(3.21, 106.16)=28.92, p<.001$ ]. Bonferroni pairwise comparisons revealed that the '1<sup>st</sup> Baseline phase' showed significantly lower systolic pressure than all the other experimental phases [all  $p<.001, >.016$ ]. The Concluding phase of the slide presentation showed significantly lower systolic pressure than both the Emotional Phase and the Neutral Phase of the slide presentation [ $p=.006$ ] and [ $p=.001$ ] respectively. There was no main effect of 'Stress Condition' on systolic pressure [ $F(1,33)=.824, p=.371$ ]. There was an 'Experimental Phase' \* 'Stress Condition' interaction [ $F(3.2, 106.16)=13.693, p=.0001$ ] on systolic blood pressure. A one way ANOVA revealed the interaction was due to the CPS group having significantly elevated systolic blood pressure for the 'CPS/Control phase' than the Control group [ $F(1,45)=14.48, p=.0001$ ] (see Figure 2.8).

**Figure 2.8** Systolic blood pressure during the course of Experiment 2. Error bars represent +1/-1 standard error of the mean.

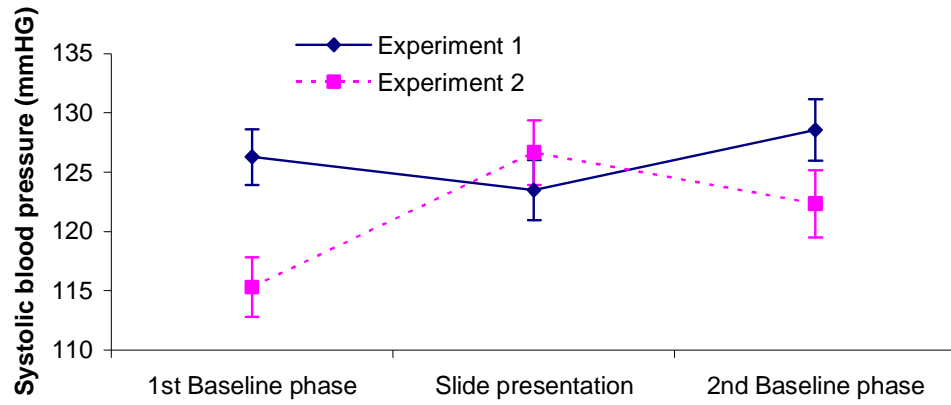


**Key:** SC= stress condition, SP= Slide presentation

#### 2.3.3.2.4 Systolic pressure: Experiment 1 versus Experiment 2

Data from both the CPS and Control groups from both Experiment 1 and 2 was included in this analysis. In order to determine whether saliva sampling in Experiment 1 acted as a stressor and elevated heart rate level inadvertently, a repeated measures ANOVA was performed with ‘Experiment’ (Experiment 1/ Experiment 2) as the between subjects factor and ‘Experimental Phase’ (1<sup>st</sup> Baseline phase, ‘Slide Presentation, ‘2<sup>nd</sup> Baseline phase’) as the within subject factor, revealing an ‘Experiment’ \* ‘Experimental Phase’ interaction on systolic pressure [F(2,148)= 24.782, p<.001]. A one way ANOVA revealed the interaction was due to higher systolic pressure in Experiment 1 for the ‘1<sup>st</sup> Baseline phase’ [p=.001]. There was no main effect of ‘Experiment’ on systolic pressure [F(1,74)= 1.808, p=.183] (see Figure 2.9).

**Figure 2.9** Systolic blood pressure: Comparing Experiment 1 & 2. Error bars represent  $\pm 1$  standard error of the mean.

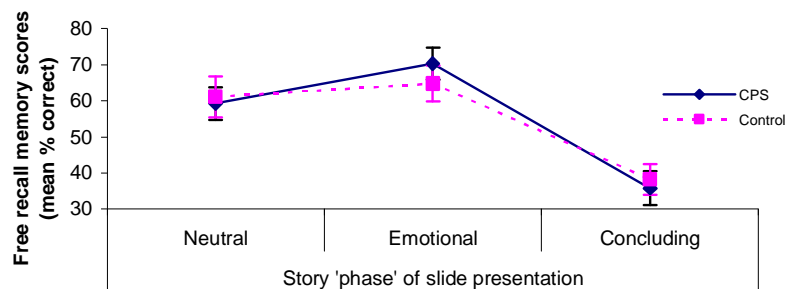


### 2.3.3.3 Memory for slide presentation Experiment 2

#### 2.3.3.3.1 Free recall memory

Repeated measures ANOVA with ‘Stress Condition’ (i.e. CPS/Control) as the between subject factor and ‘Slide Phase’ (Neutral/Emotional/Concluding) as the within subject factor revealed a significant effect of ‘Slide Phase’ on free recall memory [ $F(2,86)=29.78$ ,  $p<.001$ ]. Bonferroni pairwise comparisons revealed greater memory for the Emotional Phase than both the Neutral [ $p=.008$ ] and Concluding [ $p<.001$ ] phases. There was no main effect of ‘Stress Condition’ on memory scores [ $F(1,52)=.007$ ,  $p=.933$ ]. There was also no ‘Slide Phase’ \* ‘Stress Condition’ interaction on free recall memory scores [ $F(2,104)=.594$ ,  $p=.554$ ]. Free recall memory scores for the Neutral phase were subtracted from the memory scores for the Emotional phase to create a ‘difference score’. A one way ANOVA revealed no difference between the CPS and Control groups for this ‘difference score’ [ $F(1,52)=.905$ ,  $p=.346$ ]. (see Figure 2.10).

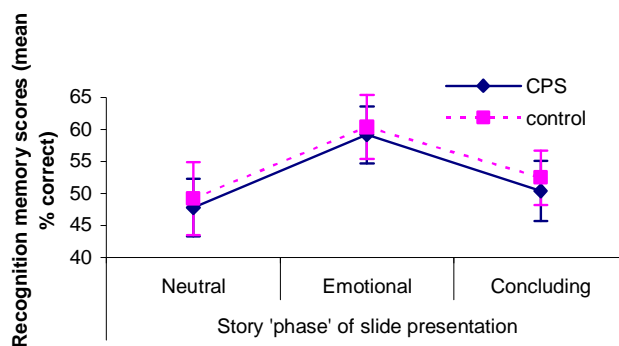
**Figure 2.10** Free recall memory for the slide presentation Experiment 2. Error bars represent +1/-1 standard error of the mean.



### 2.3.3.3.2 Recognition memory

Repeated measures ANOVA with ‘Stress Condition’ (i.e. CPS/Control) as the between subject factor and ‘Slide Phase’ (Neutral/Emotional/Concluding) as the within subject factor revealed a significant effect of ‘Slide Phase’ on recognition memory scores [ $F(2, 86)=17.57, p<.001$ ]. Bonferroni pairwise comparisons revealed greater memory for the Emotional phase than both the Neutral [ $p<.001$ ] and the Concluding [ $p=.001$ ] phases. There was also no main effect of ‘Stress Condition’ on recognition memory performance [ $F(1,52)=.444, p=.508$ ]. A repeated measures ANOVA revealed there was no ‘Slide Phase’ \* ‘Stress Condition’ interaction on recognition memory scores [ $F(2,104)=.026, p=.974$ ]. Recognition memory scores for the Neutral phase were subtracted from the Emotional phase to yield a difference score. A one way ANOVA revealed no difference between the CPS group and Control on recognition memory for this ‘difference score’ [ $F(1,52)=.007, p=.386$ ] (see Figure 2.11)

**Figure 2.11** Recognition memory scores for the slide presentation Experiment 2. Error bars represent +1/-1 standard error of the mean.





#### 2.3.3.3.3. Recognition memory for central details and peripheral details Experiment 2.

Analysis of memory scores revealed no significant findings concerning sex differences in memory scores for emotional material. The analysis also revealed a) no sex differences in memory for central and peripheral details, b) no differences between ‘Bem males’ and ‘Bem females’ in memory performance for central and peripheral details. The analysis and graphs of these findings can be found in Appendix 8.

#### 2.3.4 Discussion Experiment 2

Cardiac data revealed that CPS stress significantly elevated systolic and diastolic blood pressure, suggesting that CPS is a reliable physiological stress inducer. There was also evidence to suggest that saliva sampling during Experiment 1 may well have inadvertently caused physiological stress to participants. Comparison of systolic pressure from both experiments revealed an ‘Experiment’ by ‘Experimental Phase’ interaction. Participants in Experiment 1 showed *elevated* systolic blood pressure during the 1<sup>st</sup> baseline phase (i.e. the period when they were giving their first saliva sample) in contrast to participants in Experiment 2. However, there was no difference between Experiment 1 and Experiment 2 in systolic pressure for the emotional arousing slide presentation. Analysis of heart rate from Experiment 1 and 2 reconfirmed this pattern: as there was also an ‘Experiment’ by ‘Experimental Phase’ interaction for heart rate. This interaction was due to higher heart rate for the 1<sup>st</sup> & 2<sup>nd</sup> Baseline phases in Experiment 1 than Experiment 2 but lower heart rate for the ‘Slide presentation phase’ in Experiment 1 than Experiment 2. It is important to note that the inter-study comparison described above was performed to illustrate whether saliva sampling was acting as an inadvertent stressor, as this type of analysis is not a valid between subjects comparison.

As with Experiment 1 heart rate did not vary by slide phase in Experiment 2. However, systolic pressure showed significant decreases as the slide presentation progressed. However, this variation did not indicate that the emotionally arousing phase elicited the change in both systolic and diastolic pressure; instead there was a general decrease in systolic pressure from the beginning of the slide presentation to the end, rather than just a change occurring during the emotionally arousing phase. Therefore these findings do not suggest that emotional stimulus effectively manipulated cardiac variables. The hypothesis that post learning stress hormone activation interacts with initial arousal at encoding to enhance memory for emotional material was again not supported. There was no 'Slide Phase' by 'Stress Condition' interaction for either free recall memory or recognition memory performance. The hypothesis that males (or 'Bem males') would have enhanced memory for central details of emotional material and that females (or 'Bem females') would have enhanced memory for peripheral details of emotional material was not supported by recognition memory scores. CPS stress also did not affect memory performance for central and peripheral details for either males or females (or for 'Bem males' or 'Bem females').

## **2.4 Experiment 3**

### **2.4.1 Introduction**

Comparing cardiac data from both experiments suggested that saliva sampling may have acted as an inadvertent stressor in Experiment 1. However, Experiment 2 still failed to find an enhancing effect of post-learning stress hormone activation on memory for emotional material. It is possible that there may also have been an inadvertent stressor in

Experiment 2 that again masked the effects of stress hormone activation on memory consolidation of emotional material. In Experiment 2 participants completed the AVL T which assesses short term memory. This test required participants to recall a list of 15 words over a series of 3 trials. It is conceivable that participants may have found this test psychologically stressful. Participants in Experiment 2 were also asked to complete the Spielberger State and Trait anxiety questionnaires which some participants may have found stressful as completing it may have engendered feelings of anxiety. Considering the above, contact was made with Professor Larry Cahill's laboratory at the Centre of the Neurobiology of Learning and Memory at the University of California, Irvine, in order to develop a new methodology for a third experiment. Cahill has previously reported an enhancing effect of post-learning stress hormone activation (employing CPS stress as the stress hormone activator) on memory consolidation of emotional events (Cahill et al. 2003). A methodology for a 3<sup>rd</sup> experiment was developed in consultation with the Cahill Laboratory, in order to create an experimental design as free as possible from potential inadvertent stressors. It was decided that participants would view the slide presentation but would not complete any questionnaires, memory tests or deposit any saliva for analysis, pre or post viewing, until a second session one week later. For the 1<sup>st</sup> and 2<sup>nd</sup> 'Baseline phases' participants would simply read through magazines rather than complete questionnaires or tasks. Only after receiving free recall and recognition memory tests on the slide presentation one week later, would participant complete personality and mood questionnaires and the AVL T. This 'second session' one week later would take place face to face rather than over the phone as in Experiment 2. Therefore, a design for a 3<sup>rd</sup> experiment was created in which all identifiable stressors were removed until *after* completion of the memory tests.

Considering the previous 2 experiments failed to find an effect of sex and 'Bem sex' on memory performance for central and peripheral details it was decided not to analyse the effects of sex and Bem sex on memory for central and peripheral details in this third experiment. This decision was also based on the fact that a smaller sample size would be chosen for this study. A pragmatic reason for choosing a smaller size was due to time limitations, as a substantial period of this thesis had already been devoted to ascertaining the effects of CPS stress on memory for emotional events. Therefore, a smaller sample size was chosen to allow time for other thesis topics.

## **2.4.2 Methods**

### *2.4.2.1 Participants*

The sample size chosen for this study was smaller than for the previous two studies as explained above. Thirty participants (sixteen females & fourteen males) from the University of Stirling student population were recruited using £5 monetary reward as incentive. Six Participants (3 males, 3 females) could not be contacted by telephone for the memory tests one week later. Therefore, 24 individuals (11 males: 5 Controls, 6 CPS; 13 females: 7 Controls, 6 CPS) completed testing. Participants were recruited using the same criteria as the first two studies.

#### *2.4.2.2 Materials*

The materials used in this 3<sup>rd</sup> experiment were identical to those used in the Experiment 2.

#### *2.4.2.3 Modifications to procedure*

##### *2.4.2.3.1 First session*

For the first session, participants were asked to sit down and relax and were given a selection of current affair and popular culture magazines to have a read through. The heart rate monitor was also attached. Cardiac performance was recorded for 5 minutes before the slide presentation was presented. Immediately after viewing and rating the slide presentation, participants submerged their hand in either ice-cold (CPS stress) or lukewarm water. Following this, participants were again asked to sit and relax for 5 minutes and were provided with magazines to read through again. Cardiac performance was also recorded during this period.

##### *2.4.2.3.2 Second session (one week later)*

Participants were given the surprise free recall and recognition memory tests on the slide presentation. Participants were then given the modified version of the AVLTL as in Experiment 2. Participants then completed the pen and paper questionnaires as in Experiment 2. At the end of this session participants were fully debriefed as to the full aims of the experiment. Participants were then compensated for taking part.

## 2.4.3 Results

### 2.4.3.1 Potentially confounding variables

A one way ANOVA (corrected for multiple comparisons) revealed no differences between experimental groups on potentially confounding variables (see Table 2.3)

Reliability: Cronbach's Alpha was used to determine the internal reliability of both State and Trait anxiety questionnaires, and the Big 5 personality dimensions. For State anxiety  $\alpha = .79$ ; for Trait anxiety  $\alpha = .87$ ; for Agreeableness  $\alpha = .71$ ; for Extraversion  $\alpha = .79$ ; for Conscientiousness  $\alpha = .72$ ; for Emotional stability  $\alpha = .73$ ; for Intelligence  $\alpha = .71$ .

**Table 2.3 Potentially confounding variables Experiment 3.**

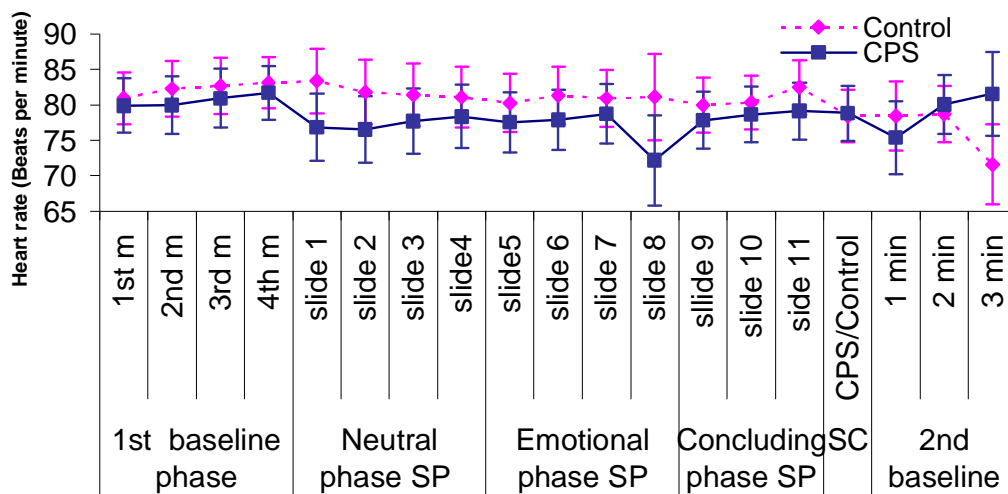
	Male Control N=5	SD	Male CPS N=6	SD	Female Control N=7	SD	Female CPS N=6	SD	F	P
Age	20.50	2.64	19.67	3.78	23.50	5.56	18.50	1.05	1.81	.19
Baseline systolic BP	144.41	33.66	160.70	35.04	169.14	50.00	155.53	31.35	0.44	.72
Baseline diastolic BP	78.79	14.08	101.87	38.35	106.85	50.47	91.28	35.65	0.64	.60
Baseline heart rate	76.62	13.63	80.85	18.65	87.84	11.73	86.28	6.71	0.86	.48
AVLT short Delay free recall	6.50	.70	10.00	1.44	11.33	2.30	9.75	2.75	1.86	.22
Emotional arousal to SP	5.00	1.58	5.40	1.57	5.33	1.86	6.60	.54	1.11	.37
Ex	-3.50	11.21	-1.33	7.09	4.40	7.70	9.67	7.99	2.25	.13
Ag	14.50	1.291	13.00	5.29	18.60	4.87	19.33	3.67	2.47	.10
Con	8.00	8.832	1.67	5.13	12.40	6.34	14.50	5.61	2.87	.07
ES	-10.75	8.342	-11.00	8.88	-12.40	8.26	-6.17	7.73	0.60	.63
In	21.00	3.162	22.33	4.04	19.80	3.11	19.17	4.62	0.52	.67
State anxiety	-11.40	15.07	-1.00	12.72	-20.50	3.10	-19.00	9.51	1.80	.20
Trait anxiety	6.00	13.33	7.67	7.63	5.50	8.02	-1.75	1.5	0.78	.53
<b>SD:</b> standard deviation, <b>BP:</b> blood pressure, <b>AVLT:</b> auditory verbal learning test, <b>SP:</b> slide presentation, <b>Ex:</b> extraversion, <b>Ag:</b> agreeableness, <b>Con:</b> conscientiousness, <b>ES:</b> emotional stability, <b>In:</b> intelligence.										

2.4.3.2 The effect of CPS stress & the slide presentation on cardiac variables for Experiment 3

2.4.3.2.1 Heart rate Experiment 3

Repeated measures ANOVA with ‘Stress Condition’ (CPS/Control condition) as the between subject factor and ‘Experimental Phase’ (‘1<sup>st</sup> Baseline phase’, ‘Neutral phase of slide presentation’, ‘Emotional phase of slide presentation’, ‘Concluding phase of slide presentation’, ‘CPS/control phase’, and ‘2<sup>nd</sup> Baseline phase’) as the between subjects factor, revealed no within subjects effect of ‘Experimental Phase’ on heart rate [ $F(2.77, 58.22)=2.32, p=.089$ ]. There was no main effect of ‘Stress Condition’ on heart rate [ $F(1, 21)=.086, p=.772$ ]. There was a significant ‘Experimental Phase’ \* ‘Stress Condition’ interaction [ $F(2.772, 58.22)= 2.919, p= .017$ ]. From viewing Figure 2.12 one can deduce this interaction was due to a decrease in heart rate in the Control group for the ‘2<sup>nd</sup> Baseline phase’. See Figure 2.12.

**Figure 2.12** Heart rate during the course of Experiment 3. Error bars represent +1/-1 standard error of the mean.



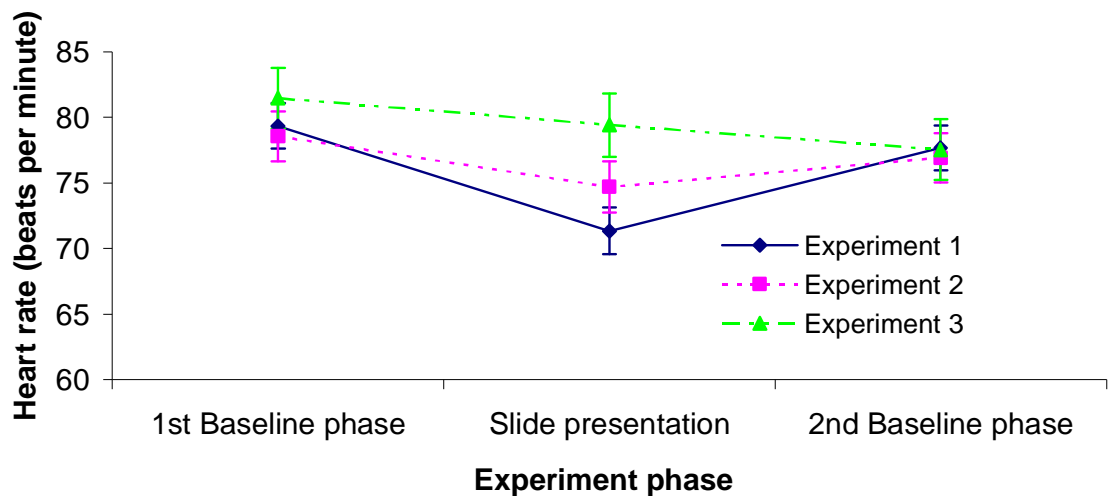
Key: SC= stress condition, SP= Slide presentation



#### 2.4.3.2.2. Heart rate: Comparing Experiments 1, 2 & 3

Data from the CPS and Control groups from Experiments 1, 2 and 3 was included in this analysis. A repeated measures ANOVA was performed with ‘Experiment’ (Experiment 1/ Experiment 2/Experiment 3) as the between subjects factor and ‘Experimental Phase’ (1<sup>st</sup> Baseline phase, ‘Slide Presentation’, ‘2<sup>nd</sup> Baseline phase’) as the within subject factor, revealing an ‘Experiment’ \* ‘Experimental Phase’ interaction on heart rate [F(2,194)=13.315, p<.001]. One way ANOVA revealed that a significantly greater heart rate for the ‘Slide presentation’ in Experiment 3 compared to Experiment 1 was responsible for this interaction. There was no main effect of ‘Experiment’ on heart rate [F(1,97)=.727, p=.486]. See Figure 2.13.

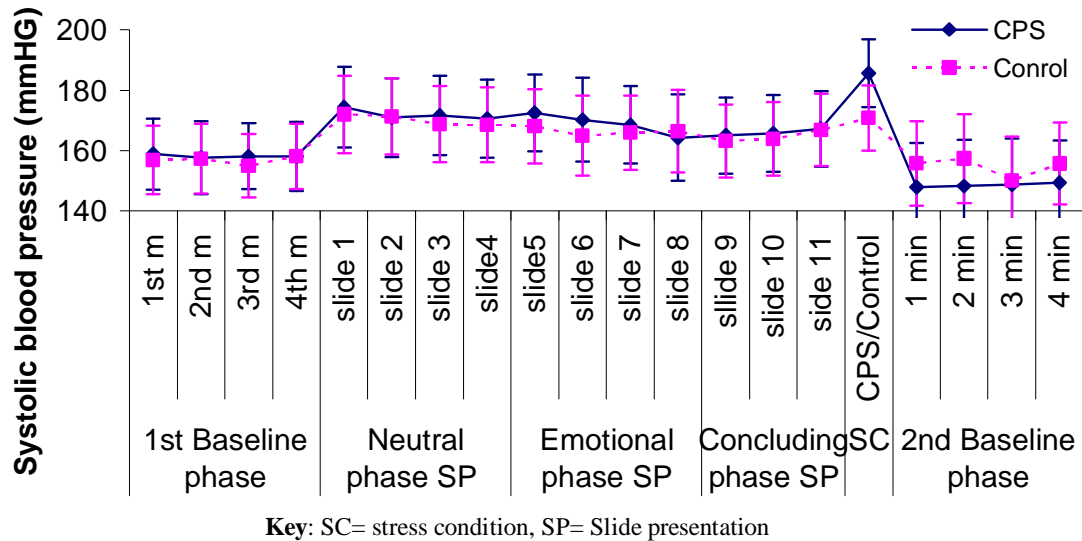
**Figure 2.13** Heart rate: Comparing Experiments 1, 2 & 3. Error bars represent +1/-1 standard error of the mean



#### 2.4.3.2.3 Systolic blood pressure Experiment 3

A repeated measures ANOVA with 'Stress Condition' (CPS/Control condition) as the between subject factor and 'Experimental Phase' ('1<sup>st</sup> Baseline phase', 'Neutral phase of slide presentation', 'Emotional phase of slide presentation', 'Concluding phase of slide presentation', 'CPS/control phase', and '2<sup>nd</sup> Baseline phase') as the within subjects factor revealed a within subjects effect of 'Experimental Phase' on systolic blood pressure [ $F(1.7,35.7)=12.49, p<.001$ ]. Bonferroni pairwise comparisons revealed that blood pressure for the '1<sup>st</sup> Baseline phase' was lower than for the all phases of the slide presentation [all  $p<.027$ ], and the 'CPS/Control phase' [ $p<.001$ ]. Systolic pressure for the '2<sup>nd</sup> Baseline phase' was lower than for the Neutral phase of the slide presentation [ $p=.035$ ] and the 'CPS/Control phase' [ $p=.004$ ]. Systolic blood pressure was significantly greater for the Neutral phase of the slide presentation than for the Concluding phase [ $p=.008$ ]. There was no main effect of 'Stress Condition' [ $F(1,21) =.024, p=.880$ ] or no 'Experimental Phase' \* 'Stress condition' interaction on systolic blood pressure [ $F(1.7,35.7)=1.594, p=.168$ ]. See Figure 2.14.

**Figure 2.14** Systolic blood pressure during the course of Experiment 3. Error bars represent +1/-1 standard error of the mean

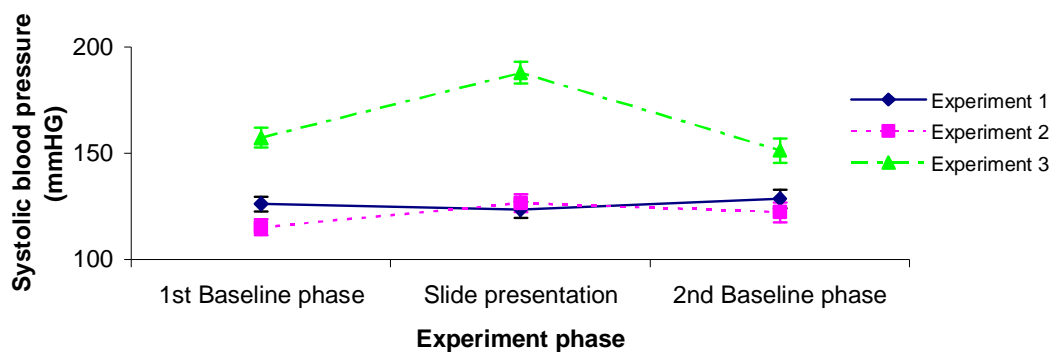


#### 2.4.3.2.4 Systolic blood pressure: Comparing Experiments 1, 2 & 3

Data from the CPS and Control groups from Experiments 1, 2 and 3 was included in this analysis. A repeated measures ANOVA was performed with ‘Experiment’ (Experiment 1/ Experiment 2/Experiment 3) as the between subjects factor and ‘Experimental Phase’ (‘1<sup>st</sup> Baseline phase’, ‘Slide Presentation’, ‘2<sup>nd</sup> Baseline phase’) as the within subject factor, revealing an ‘Experiment’ \* ‘Experimental Phase’ interaction on heart rate [F(1.42, 135.94)=11.8, p<.001]. Bonferroni pairwise comparisons revealed greater systolic blood pressure for the ‘Slide Presentation’ than either the ‘1<sup>st</sup> Baseline phase’ [p<.001] or the ‘2<sup>nd</sup> Baseline phase’ [p<.005]. There was a main effect of ‘Experiment’ on blood pressure [F(1,96)=19.9, p<.001]. Pairwise comparisons revealed significantly higher systolic blood pressure for Experiment 3 than for Experiment 2 or Experiment 1 for each ‘Experimental Phase’ [all p<.001]. There was an ‘Experimental Phase’ \* ‘Experiment’ interaction

[ $F(1.42, 135.94)=12.59, p<.001$ ] (see results section Experiment 2 for interaction between Experiment 1 & Experiment 2). One can deduce from Figure 2.15 that this finding is primarily due to enhanced systolic blood pressure for the Slide Presentation phase in Experiment 3 than in both Experiments 1 & 2.

**Figure 2.15** Systolic blood pressure: Comparing Experiments 1, 2 & 3. Error bars represent +1/-1 standard error of the mean



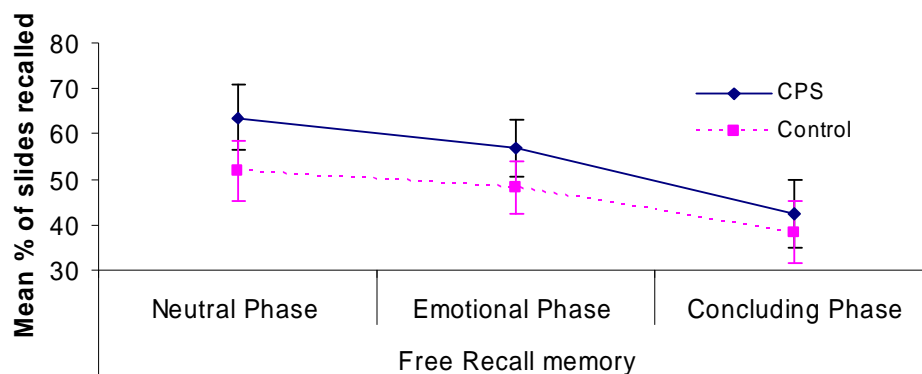
### 2.4.3.3 Memory for slide presentation

#### 2.4.3.3.1 Free recall memory Experiment 3

A repeated measures ANOVA with ‘Stress Condition’ (i.e. CPS/Control) as the between subject factor and ‘Slide Phase’ (Neutral/Emotional/Concluding) as the within subject factor revealed a significant effect of ‘Slide Phase’ on free recall memory [ $F(2,44)=5.948, p=.005$ ]. Bonferroni pairwise comparisons revealed significantly greater memory for the Neutral phase than the Concluding phase [ $p=.017$ ]. There was no main effect of ‘Stress Condition’ on free recall memory scores [ $F(1,22)=1.24, p=.278$ ]. The analysis revealed there was no ‘Slide phase’ \* ‘Stress Condition’ interaction on free recall memory scores

[ $F(2,44) = .288, p = .751$ ]. Free recall memory scores for the Neutral phase were subtracted from the Emotional phase to create a ‘difference score’. A one way ANOVA revealed no difference between the CPS and the Control group on this measure [ $F(1,22) = .104, p = .751$ ]. See Figure 2.16

**Figure 2.16** Free recall memory for slide presentation Experiment 3. Error bars represent  $\pm 1$  standard error of the mean

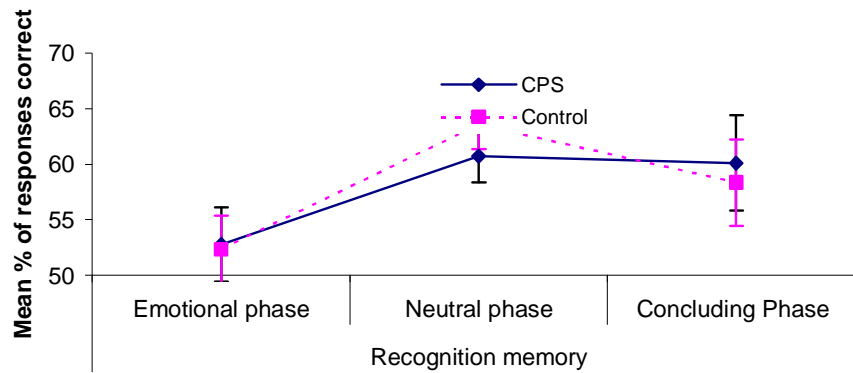


#### 2.4.3.3.1 Recognition memory Experiment 3

A repeated measures ANOVA with ‘Stress Condition’ (i.e. CPS/Control) as the between subject factor and ‘Slide Phase’ (Neutral/Emotional/Concluding) as the within subject factor revealed a significant effect of ‘Slide Phase’ on recognition memory [ $F(2,40) = 5.953, p = .005$ ]. There was also no main effect of ‘Stress Condition’ [ $F(1,20) = .002, p = .967$ ]. There was also no ‘Slide Phase’ \* ‘Experimental Condition’ interaction on recognition memory scores [ $F(2,40) = .473, p = .627$ ]. Recognition memory scores for the Neutral phase were subtracted from those of the Emotional phase to create a ‘difference score’. A one way ANOVA revealed no difference between the CPS and Control group on this measure [ $F(1,20) = .430, p = .519$ ]. See Figure 2.17

**Figure 2.17** Recognition memory performance for slide presentation Experiment 3.

Error bars represent +1/-1 standard error of the mean



#### 2.4.4 Discussion Experiment 3

Cardiac data revealed high baseline values for heart rate and systolic blood pressure. This was not expected as the baseline periods were designed to be as stress free for participants as possible. However, these high baseline values may be partially due to the relatively small sample size that was used in Experiment 3. The results of heart rate and blood pressure analysis suggest that the Emotional phase of the slide presentation did not effectively manipulate cardiac variables. The hypothesis that post learning stress hormone activation interacts with initial arousal at encoding to enhance memory for emotional material was again not supported. There was no 'Slide Phase' by 'Stress Condition' interaction for either free recall or recognition memory performance.

## 2.5 General discussion

Comparison of cardiac variables from Experiments 1, and 2 suggest that saliva sampling may have inadvertently compromised the specific aim of the first experiment: to investigate the effect of post learning stress hormone activation on memory performance of emotional material. However, even with saliva sampling removed, the results of Experiment 2 again failed to support the above hypothesis, suggesting that the phenomenon under investigation: ‘post learning stress hormone activation interacts with initial arousal at encoding to enhance memory for emotional material’, is not robust and replicable. The methodology for Experiment 3 was designed in consultation with the Cahill laboratory to be as free from as many inadvertent stressors as possible for participants. Nevertheless, the results of Experiment 3 are also in contrast with those of Cahill & Alkire (2003), Cahill et al. (2003) and Andreano & Cahill (2005) who found that post learning stress hormone activation interacted with initial arousal at encoding to enhance memory for the ‘to be remembered stimulus’. It may be argued that the stimulus used in the present series of experiments is not sufficiently arousing in order to trigger an interaction of ‘initial arousal’ with ‘post learning’ stress hormone activation. Analysis of cardiac variables suggests this may be the case, as systolic blood pressure and heart rate did not showing the expected variation according to slide phase for Experiments 1, 2 and 3. Considering the present research was specifically interested in how post learning stress interacts with degree of arousal at *initial encoding* it may be argued that the stimulus used may have been unable to produce sufficient arousal at initial encoding for the subsequent stress hormone activation to interact with, in order to modulate memory consolidation. However, results of free recall and recognition memory scores show that participants did have enhanced memory for the Emotional phase in comparison to the other two phases, indicating that the stimulus is sufficiently arousing to enhance memory. Additionally, Andreano & Cahill (2005) found an enhancing effect of post learning CPS stress on

memory consolidation of a relatively neutral narrative. Therefore, it may not be the stimulus per se that is the problem. Instead, it may be the fact that the emotional stimulus and the ‘stressor’ are not *intrinsically linked* that is responsible for this null finding.

### *2.5.1 Extrinsic versus intrinsic arousal to emotional stimulus*

It is possible that the stimulus inducing the physiological arousal is crucial in memory consolidation for emotional material. In the three experiments presented here the physiological arousal was not intrinsically linked to the emotionally arousing stimulus, i.e. the CPS stress bore no relationship to the slide presentation. Libkuman, Nichols-Whitenead, Griffith & Thomas (1999) also found that extrinsic physiological arousal (induced by running energetically on a treadmill) while viewing an emotionally arousing slide presentation also failed to enhance memory consolidation for emotional material. However, Nielson, Yee & Erickson (2005) did find that inducing emotional arousal that was not semantically related to the ‘to be learned’ stimulus did enhance memory for that stimulus. Therefore, the literature on the importance of linking arousal to the stimulus remains unresolved and further research is needed to elucidate the importance of the semantic relationship between the source of arousal and the emotional stimulus.

### *2.5.2 Future research*

Future research should aim to semantically link the arousal inducer to the stimulus ‘to be remembered, in order to determine if this method has greater success at finding an enhancing effect of stress on memory consolidation of emotional material. Considering cardiac data indicate that the slide presentation did not have any discernible effect on heart rate and blood pressure, future research in this area should perhaps look at alternative stimuli that may elicit a more robust arousal response in participants. The IAPS is a



compilation of images extensively used in psychophysiological research. Images from the IAPS (Lang et al. 1999) were employed by both previous studies to have found support for the phenomenon under investigation. Alternatively, the results of this study may reflect limitations of a static slide show presentation as an arousing stimulus. Future research should look to employ a motion video rather than a slide show as this has the capacity to be more realistic and thus more emotionally arousing. It is also possible that the emotional material in the slide presentation was a source of stress and may have been responsible for the enhanced memory for the Emotional phase in Experiments 1 and 2. Future research should investigate this possibility by implementing a two (emotional, neutral narrative) x two (CPS, control) experimental design in order to investigate whether the possibility that stress induced by the emotional narrative is sufficient for memory enhancement to occur.

### *2.5.3 Conclusion*

The results of these three experiments suggest that the enhancing effect of post-learning CPS stress administration is not a robust and replicable phenomenon. The results of these studies also suggest that the previously documented effects of males showing enhanced memory for central details of an emotionally arousing event, compared to females, and females showing enhanced memory for peripheral details of an emotionally arousing event, compared to males, are not robust and replicable phenomena. These findings force a re-examination of what is known about post learning stress's effect on memory consolidation for emotional material. The suggestion is made for future research to employ (a) intrinsically linked material to be remembered, (b) alternative visual stimuli, (c) video, rather than static, stimulus material.

### **Chapter 3. Examining the effect of C6 total spinal cord transection on emotional awareness, expressivity and memory for emotional material.**

#### **3 Abstract**

*Objective:*

*To investigate whether total C6 spinal cord transection*

- 1) Reduces emotional expressivity and emotional awareness for self and others
- 2) Impairs memory for emotional material

*Method:*

Twenty four spinal cord injury (SCI) patients, 20 Orthopaedic injury control (OIC) patients (matched for age, sex and education) and 20 healthy young adults participated in this study. Participants completed the Levels of Emotional Awareness Scale (LEAS; which is designed to assess positive emotional expressivity, negative emotional expressivity and strength of emotional expressivity), the Berkeley Expressivity Questionnaire (BEQ; designed to assess positive emotional expressivity, negative emotional expressivity and strength of emotional expressivity), and viewed a slide presentation depicting emotionally arousing material. Thirty minutes following viewing of the emotionally arousing slide presentation participants received a free recall and recognition memory test of the slide presentation.

*Results:*

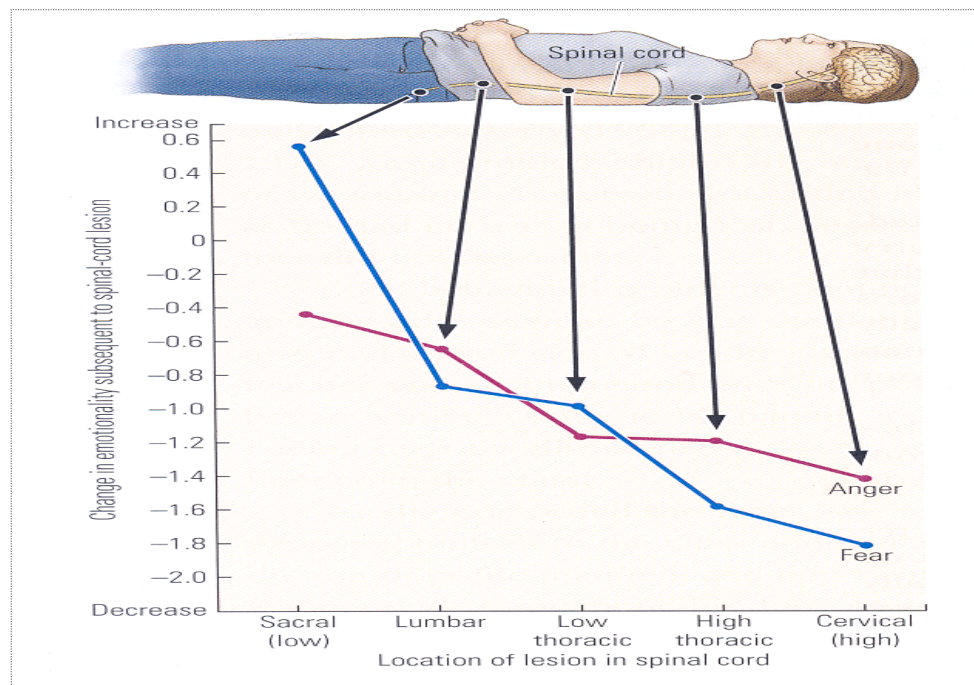
Results of the study revealed no difference between the 3 study groups on BEQ variables. SCI patients reported greater levels of strength of emotional expressivity and mean emotional expressivity after, rather than before, spinal cord injury. The SCI and OIC groups did not differ on any of the LEAS variables. Analysis of memory scores on the slide presentation revealed no evidence that SCI leads to impairment in memory for emotional events.

*Conclusion:*

The mainstream view in the cognitive neuroscience of emotion is that spinal cord injury impairs emotional capacities, the extent of which is greater the higher up the spinal cord the lesion occurs. The findings of this study contradict this widely held view.

### 3.1 Introduction

The prevailing view on the effect of spinal cord injury on affective functioning is derived from a seminal study by Hohmann (1966) who interviewed 25 patients with spinal cord injury, and asked them to compare emotional feelings as experienced before injury, with equivalent post-injury experiences. The patients reported experiencing a decline in the intensities of feelings of anger and fear; with the decline in intensity more marked the higher the lesion was up the spinal cord (higher lesions result in more acute decreases in neural feedback from the body to the brain). This has proved to be a remarkably influential study; for example, the latest (6<sup>th</sup>) edition of the undergraduate Psychology textbook *An Introduction to Brain and Behaviour*, (Kolb & Whishaw 2005) reaffirms the conclusion drawn by Hohmann by stating that the emotional loss is greater the higher the lesion is up the spine (see Figure 3.1).



**Figure 3.1.** Kolb & Whishaw produce the above graph in their introductory psychology textbook *An Introduction to Brain and Behaviour* (2005, p.433). The graph is adapted from the work of Hohmann (1966) and displays how the higher up the spine the lesion the greater the impairment in emotionality for anger and fear.

Montoya and Schandry (1994) also reported impaired emotional experience and heartbeat perception in patients with spinal cord injury. This viewpoint also finds support from the influential neurologist Antonio Damasio who asserts: “all the surveys of patients with spinal cord damage ... have revealed some degree of impaired feeling as one should have expected given that the spinal cord is a *partial conduit* for relevant body input” (Damasio 1999, p.289). When making this assertion Damasio draws upon the work of Hohmann (1966) and Montoya & Schandry (1994). Damasio (1999, p. 289) goes on to assert “one undisputed fact emerged in these studies: the higher the placement of damage in the spinal cord, the more impaired feeling is.”

This mainstream view has overlooked research that has failed to find a decrement in emotional capacities as a result of spinal cord injury. However, much of this research has used informal qualitative designs and/or small sample sizes. For example, Dana’s (1921) finding of no reported decrement in emotional feeling, one year after SCI, was based on the account of only a single patient. Lowe & Carroll (1985), Bermond et al. (1987), Chwalisz et al. (1988) and Bermond et al. (1991) used larger samples sizes and also reported no affect of SCI on affective state. However, these studies implemented qualitative designs similar to that of Hohmann (1966), whereby participants were interviewed by experimenters in a less structured format leaving the results of the studies more susceptible to experimenter bias.

### *3.1.1 Contemporary quantitative research*

More recent research has implemented more quantitative research designs in an attempt to investigate the effects of SCI on emotional capacities. For example, North & O’ Carroll (2001) tested Damasio’s somatic marker hypothesis (1994; 1999) (which states that bodily

feedback to the brain can influence behaviour and decision making) in patients with SCI using the Iowa gambling task and found no difference in performance on the task between SCI patients and controls. O' Carroll, Ayling, O' Reilly & North (2003) employed quantitative measures to investigate whether Alexithymia (a term employed to describe individuals who have difficulty in identifying, describing and expressing emotion (Sifneos 1972)), was greater in spinal injury patients than age and sex matched healthy controls, and found no difference between the two groups in Alexithymia scores. Both these above studies seem to suggest that other feedback systems are still functioning in spinal injury patients, i.e. hormonal feedback via the bloodstream and feedback via cranial nerves and the vagus nerve, and that these feedback routes may have an important role to play in perceiving, identifying and experiencing emotion (North & O' Carroll, 2001; O' Carroll et al. 2003). Additionally, Cobos et al. (2002) presented a series of emotionally arousing pictures to 19 spinal injured patients and 19 healthy control participants matched for sex, age and education, while simultaneously recording heart rate. Both groups showed a significantly greater change in heart rate while viewing unpleasant pictures than while viewing pleasant pictures, and subjective measures of arousal showed no difference between both groups. Looking within the spinal injury group; the level, extension and duration of the lesion provided no evidence for a decreased emotional experience.

Despite the fact that recent investigations of the effects of SCI on emotional capacities have employed more quantitative designs and larger sample sizes, the view originally inspired by Hohmann (1966), and most strongly endorsed by the prominent neurologist Antonio Damasio, remains the most widely held and influential view. The critical mass of research which would lead to this viewpoint being thoroughly reconsidered and reviewed has not yet been reached. This Chapter aims to further investigate the effects of SCI on emotional capacities by employing a quantitative research design so as to negate any

possible experimenter bias. This Chapter will also examine, for the first time, the effects of total spinal cord transection on memory consolidation for emotional events.

### *3.1.2 The present study*

The present study aims to extend findings of previous research by specifically investigating whether levels of emotional expressivity and the capacity to be aware of, and identify emotions in the self and in others, is diminished in individuals with spinal cord injury. Spinal cord injury (SCI) patients with a complete lesion at the C6 level will be tested along with age, sex and education matched orthopaedic injury control (OIC) patients and a sample of healthy controls (HC) drawn from University of Stirling Psychology undergraduates. In order to measure levels of emotional expressivity and intensity of emotional expressivity in SCI patients, participants completed the Berkeley Expressivity Questionnaire (BEQ). In order to assess emotional awareness of self and of others in SCI patients, participants also completed the Levels of Emotional Awareness Scale (LEAS).

#### *3.1.2.1 Emotional arousal and memory for emotional material*

This study will also examine whether spinal cord transection impairs memory for emotional material. Research has demonstrated that people show enhanced memory for emotionally arousing compared to emotionally neutral stimuli (e.g. Cahill & McGaugh 1998). If spinal cord injury reduces the capacity to be emotionally aroused in response to an emotional event, one would therefore expect people with spinal cord injury to have reduced memory for emotional events compared to healthy individuals. Research suggests that the release of stress hormones during emotionally arousing events are responsible for enhanced memory for that event (McGaugh 2000). Recent research concerning feedback

from the body to the brain indicates that an afferent neural system, involving the lamina 1 spinothalamocortical pathway (which represents all aspects of the physiological condition of the body), enables us to perceive feelings, mood, energy levels, stress and emotional disposition (Craig 2002). Lack of such feedback during an emotional event (due to a severed spinal cord) may lessen the intensity of emotional arousal, thus reducing stress hormone activation, which as stated above is thought to play a key role in memory consolidation of emotional events. In order to test this hypothesis, SCI patients will be shown a slide presentation containing some emotionally arousing material and after a 30 minute delay period have their memory tested for the presentation.

*3.1.2.2 Aims of study: To investigate whether complete C6 spinal cord injury transection:*

- 1) Reduces emotional expressivity and emotional awareness of self and others.
- 2) Impairs memory for emotional material

## **3.2 Methods**

### *3.2.1 Participants*

Twenty four SCI patients, 20 age, sex and education matched OIC patients and 20 HCs (from the Stirling University student population) participated in this study. See Table 3.1 for age, 'time since injury', gender and education details for each of the 3 study groups. Power analysis was employed to determine the appropriate sample size to use in this study using the software program GPower™. An effect size of .4, with Alpha set at .05, Power at .8 and number of between subjects groups at 3, was entered into the program. This program computed a total sample size of approximately 66 participants as being

appropriate for this study. Due to time limitations and the difficulties involved in recruiting patients with SCI to take part in this study, a total of 64 participants were tested.

**Table 3.1.** Comparison of three participant groups for age, ‘time since injury’, sex and education.

Participants	AGE (years):		TSI (months)		Sex		Education (years)	
	Mean	SD	Mean	SD	Male	Female	Mean	SD
SCI	40.96	14.36	24.6	9.8	17	7	12.70	1.98
OIC	40.42	11.98	29.87	4.84	12	8	12.88	2.40
HC	20.4	2.99	N/A		9	11	14.98	1.33

**Key.** SCI= spinal cord injury patients, OIC= orthopaedic injury control patients, HC= healthy control participants, SD= standard deviation, TSI = time since injury (months)

### 3.2.1.1 SCI patients

SCI patients were recruited to take part in the study from Salisbury District Hospital and Glasgow Southern General Hospital. Ethical clearance to contact suitable patients in Salisbury District Hospital and to inform them of the nature of the study and whether they would like to take part was granted from the South West Local Research Ethics committee. Twenty patients from Salisbury District Hospital and 4 from Glasgow Southern General Hospital agreed to take part and completed the study. The experimenter liaised with medical staff at Salisbury District Hospital and informed them of the nature and purpose of the study. The medical staff then facilitated the experimenter in the recruitment of suitable SCI patients. The patients from Salisbury District Hospital completed the study in the Spinal ward at the hospital. Ethical clearance to contact patients from Glasgow Southern General Hospital was granted by the South Glasgow Research Ethics Committee.



Following this, a list of suitable participants was provided by the Glasgow Southern General Hospital Spinal Injury Unit. Patients were then contacted by telephone and informed of the nature of the study. Patients who expressed an interest in taking part in the study were informed that they could participate in the study at the Spinal Ward of Glasgow Southern General Hospital or that the experimenter could come to their homes to complete the study. All Glasgow Southern General Hospital patients agreed to participate in the study from their homes. Only SCI patients who were at least six months post injury were recruited to take part in the study, this measure was to ensure patients at time to come to terms with their injury and for any emotional changes that may have occurred as a result of the injury, to manifest.

#### *3.2.1.1.1 Spinal-cord injury classification*

Severity of spinal injury was assessed using the American Spinal Injury Association's standards for Neurological and Functional Classification of Spinal Cord Injury (ASIA 1992). This method of assessment allows the clinician to determine whether the SCI is complete or incomplete and produces a number of measures of neurological damage, including the neurological, sensory and motor level of the lesion. It also permits one to determine if there are any zones of partial preservation. All the spinal injury patients included in this study were assessed as having a complete transverse lesion of the spinal cord at the C6 level, in the absence of head trauma. Patients with total transection at the C6 level were chosen for this study as the higher the lesion the greater the loss of bodily feedback which is proposed to lead to reduced emotional capacities (see Figure 3.1). The functional consequences of a lesion at this level are that the patient is rendered quadriplegic, paralyzed from the shoulders down with no control over bowels and bladder. All patients were unaware of physical sensations from below the shoulders.

### *3.2.1.2 OIC & Healthy control patients*

OIC patients were recruited from Salisbury district hospital, following ethical clearance granted by South West Local Research Ethics Committee. Twenty patients agreed to take part, and completed the study at the hospital in the Rehabilitation unit. These patients were recruited so as to attempt to control for experience of a traumatic injury and experience of hospitalisation. Twenty healthy controls (HC) were recruited from the University of Stirling student population and were awarded course credits for completion of the study.

Orthopaedic control patients were patients who had previously suffered an injury involving a fractured or broken bone(s) requiring hospital treatment, and were currently enrolled in a rehabilitation program at Salisbury District hospital.

### *3.2.1.3 Exclusion criteria for all participant groups*

Participants were not included in the study if they had any previous history of head injury, alcohol/drug abuse or psychiatric history.

### 3.2.2 *Materials*

#### 3.2.2.1 *Hospital Anxiety and Depression Scale*

The Hospital Anxiety and Depression Scale (HADS) is a brief self-report questionnaire developed by Zigmond & Snaith (1983) to assess the levels of anxiety and depression among patients in non-psychiatric hospital clinics. The HADS scale consists of 14 items (7 for each subscale). Each item is rated on a 0-3 scale, thus the maximum score for each subscale is 21. The items do not include physical indicators of psychological distress such as headache or weight loss, which would result in false positive responses due to the medical illness. See Appendix 12 for a copy of the HADS (Zigmond & Snaith 1983).

#### 3.2.2.2 *Berkeley Expressivity questionnaire*

The Berkeley Expressivity Questionnaire (BEQ) (see Appendix 10) is a 16-item self report measure of individual differences in emotional expressivity (Gross & John 1995). The BEQ yields a total expressivity score (mean BEQ), and has three subscales: Negative Expressivity, Positive Expressivity, and Impulse Strength. The Positive Expressivity subscale is derived from responses to statements such as, “When I’m happy, my feelings show.” The Negative Expressivity subscale is derived from responses to statements such as, “Whenever I feel negative emotions, people can easily see exactly what I’m feeling.” The third subscale, Impulse Strength, provides a general measure of experience of emotion, and includes items such as, “I have strong emotions.” Participants are asked to rate how true each statement is for them on a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). Scores on the three subscales correlate about .50 with one another (Gross & John 1997). For the purpose of this study SCI patients were firstly asked

to complete the BEQ according to how they feel “now at this very moment, not how you would like to see yourself in the future or how you saw yourself in the past”. Following this, SCI patients were then asked to complete the BEQ again but were asked to respond “according to how you think you would have been prior to your spinal injury”. Only SCI patients were asked to complete the second trial of the BEQ.

### *3.2.2.3 Levels of emotional awareness scale*

The LEAS (Lane et al. 1990; see Appendix 11) is designed to measure emotional awareness in self and others and consists of 20 hypothetical scenes. Each scene is described in two to four sentences and involves two people (Lane et al. 1990). For the purpose of this study, 5 items were removed as they described actions C6 SCI patients would be unable to participate in, due to the physical restriction induced by their spinal injury. For this reason they were deemed unethical to include. The fifteen remaining scenes are designed to elicit fear, anger, sadness and happiness at five increasingly complex levels (Lane & Schwartz 1987). Each scene is read aloud to participants and then they are asked to respond to the questions: “How would you feel?” and “How would the other person feel?”. A score of 0 is given for non-emotional responses, such as a thought or a cognitive state. A score of 1 is awarded for awareness of a physiological state (e.g. “I’d feel tired”). A score of 2 scores reflects relatively undifferentiated emotion (e.g., “I’d feel bad”), or an action tendency (e.g., “I’d feel like banging my head). For a differentiated emotion, a score of 3 is rewarded, for example, “I’d feel sad”. If a participant reports two or more opposing (e.g., “I would feel happy and sad”) or distinct (e.g., “I would feel angry and surprised”) emotions they receive a score of 4. The total score for each item is the larger of the two scores, except in the case of two level four scores, which is given a total score of five. The total score from each item is summed in

order to generate a maximum possible total score of 75 (Novick-Kline, Turk, Mennin, Hoyt & Gallagher 2005). The LEAS has been shown to be useful in determining the accuracy of alexithymic individuals in recognizing emotion (Lane et al. 2000). Level one scenarios cue for bodily sensations. Level two scenarios cue for an action tendency. Level three scenarios cue for the experience of emotional extremes. Level four scenarios cue for mixtures of emotions that are differentiated and that may have opposing emotions concurrently experienced. Finally, level five scenarios cue for more complex and differentiated emotion states (Novick-Kline, et al. 2005; Lane et al. 2000).

#### *3.2.2.4 Cahill slide presentation*

For analysis purposes the slide presentation can be partitioned into three distinct phases: 1) Neutral phase, 2) Emotional phase, 3) Concluding phase. This study is particularly interested in comparing between groups on memory for the Emotional phase. See *Methods* Chapter 2 for full description.

#### *3.2.2.5 Auditory Verbal Learning Test (AVLT)*

See *Method* Chapter 2 for full description of AVLT. For the purpose of this study participants were asked to repeat back the list of 15 words twice rather than five times to make the task mentally less demanding, and to reduce the overall time of the study, so the study would be less taxing on the SCI and OIC patients. This test was administered to assess memory for neutral material so as to ensure the three groups taking part in this study are well matched for baseline memory ability.

### 3.2.3 Procedure

During the recruitment process all SCI patients were informed that the study was primarily interested in examining the emotional reaction of patients with SCI to emotionally arousing stimuli, and whether partial blocking of messages from the body to the brain, as is the case with people with SCI, causes changes in the way emotions are experienced. Participants were not informed of the surprise memory tests on the slide presentation, instead they were told: “Like much psychological research the design of the study means that you cannot be informed beforehand about certain minor aspects of the procedure because it might bias the results. However, there will be full debriefing at the end of the session”.

SCI patients from Salisbury District hospital completed the experiment either from their beds or in a wheel chair in a specially designated room. A witness (either a Nurse or relative) signed the consent form for Salisbury SCI patients. SCI patients from Glasgow Southern General Hospital completed the study in their homes. A witness (either a nurse or relative) signed the consent form for Glasgow SCI patients. SCI participants responded verbally to questionnaire questions and the experimenter recorded their responses via pen and paper. Participants initially completed a Demographics questionnaire and then viewed the Cahill slide presentation (accompanied by an audio narrative), on a laptop computer. Participants then rated how emotionally arousing they thought the slide presentation was on a scale of ‘1 to 10’. ‘1’ represented not at all emotional and 10 represented “very emotional”. Participants then completed a modified version of the AVLTL, followed by the LEAS, then the BEQ. Participants then completed a free recall, followed by a recognition memory test, of the slide presentation. Participants were then fully debriefed to the full aims of the study

### **3.3 Results**

#### *3.3.1 Potentially confounding variables*

##### *3.3.1.1 Age*

ANOVA revealed a significant difference between the study groups for age [F(2,63)=22.036,  $p<.001$ ] (see Table 3.1). Bonferroni pairwise comparisons revealed no difference between the OIC and SCI patients [ $p=1$ ], but did reveal that healthy controls were significantly younger than both orthopaedic controls [ $p<.001$ ] and spinal injury patients [ $p<.001$ ].

##### *3.3.1.2 Time since injury*

An independent samples t-test revealed no difference in ‘time since injury’ between the OIC and SCI patients [ $t= 1.47$ ,  $df=42$   $p=.153$ ]. See Table 3.1 for ‘time since injury’ means and standard deviations of both participant groups.

##### *3.3.1.3 Years of education*

ANOVA revealed a significant difference between the 3 study groups for years enrolled in full time education [F(2,63)=8.324,  $p=.001$ ]. Bonferroni pairwise comparisons revealed no difference between the orthopaedic control and the spinal injury patients [ $p=1$ ] but did reveal that healthy controls had significantly more years enrolled in full time education than orthopaedic controls [ $p=.003$ ] and spinal injury patients [ $p=.002$ ].

#### 3.3.1.4 Sex

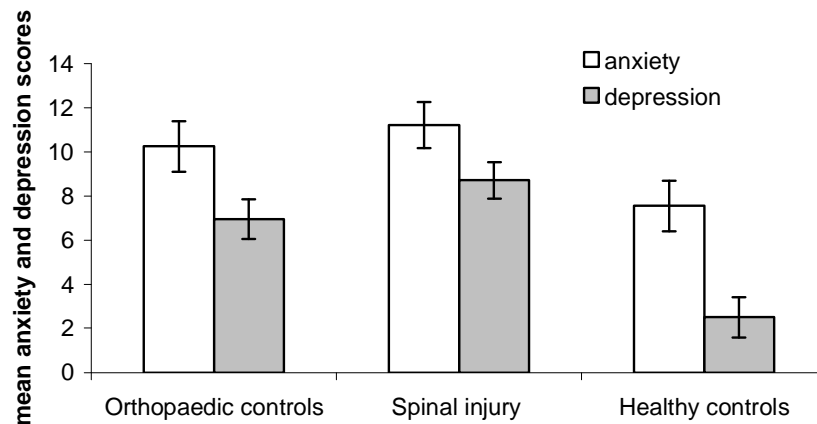
Chi-square analysis revealed no difference between the 3 study groups in the frequency of males to females within each group [ $\chi^2=3.02$ ,  $df=2$ ,  $p=.221$ ]. See Table 3.1 for frequency values of males and females within each group

#### 3.3.1.5 HADS

Cronbach's Alpha was used to determine the internal reliability of the anxiety and depression dimensions of the HADS: for HADS depression  $\alpha = .80$ ; for HADS anxiety  $\alpha = .84$ . A MANOVA was performed on HADS scores with study group as the between subjects factor and HADS anxiety and HADS depression as the within subject variables. Analysis revealed almost a significant main effect of study group for anxiety [ $F(2,63)=2.919$ ,  $p=.062$ ] and a significant main effect of depression [ $F(2,63)=13.53$ ,  $p<.001$ ]. Bonferroni pairwise comparisons revealed no difference between the SCI and OIC groups for either anxiety [ $p=1$ ] or depression [ $p=.459$ ]. The HC group showed almost significantly less anxiety than the SCI group [ $p=.064$ ] and significantly less depression than both the SCI [ $p=.003$ ] and OIC groups [ $p<.001$ ]. See Figure 3.2.



**Figure 3.2** HADS scores for OIC, SCI and HC groups. Error bars represent +1/-1 standard error of the mean.



### 3.3.1.6 AVLT

A one way ANOVA was performed on AVLT scores with study group as the between subjects factor and AVLT delay score as the dependent variable. The analysis revealed a significant main effect of study group on AVLT scores [ $F(2,61)= 3.34, p=.038$ ].

Bonferroni pairwise comparisons reported significantly greater memory for the HC group than the SCI group for AVLT scores [ $p=.038$ ]. Critically, however, there was no difference between SCI and OIC groups for AVLT scores [ $p=.348$ ].

### 3.3.1.6 Summary of potentially confounding variables

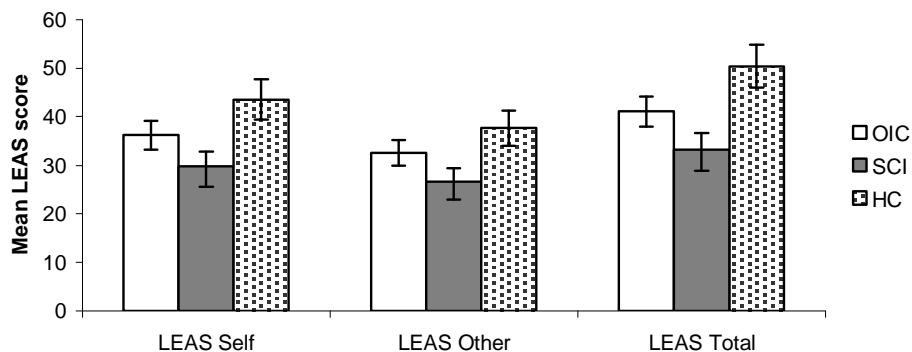
For subsequent analyses in this study, concerning LEAS and BEQ scores; age, years of full time education, and HADS anxiety and depression were entered as covariates. AVLT scores were entered as covariates for analyses concerning memory performance for the emotional slide presentation.

### 3.3.2 Levels of emotional awareness Scale (LEAS)

Internal reliability for the LEAS scores was calculated separately for LEAS self, LEAS other and LEAS total, using Cronbach's Alpha. For LEAS self  $\alpha = .80$ ; for LEAS other  $\alpha = .79$ ; LEAS total  $\alpha = .91$ . A MANOVA with study group as the between subjects factor, LEAS self, LEAS other & LEAS total as the within subjects factor and LEAS score as the dependent variable was performed. The analysis revealed an almost main effect of study group for LEAS Self [ $F(2,61)=2.865$ ,  $p=.066$ ], LEAS Other [ $F(2,61)=2.489$ ,  $p=.092$ ], and a significant main effect of study group for LEAS Total [ $F(2,61)=3.746$ ,  $p<.030$ ].

Bonferroni pairwise comparisons revealed the SCI and OIC groups did not differ for LEAS Self [ $p=.282$ ], LEAS Other [ $p=.261$ ], and LEAS Total scores [ $p=.189$ ]. HCs, however, did score marginally significantly higher than SCIs for LEAS Self [ $p=.086$ ], but not for LEAS Other [ $p=.149$ ], and significantly higher for LEAS Total [ $p<.036$ ]. HCs and OICs did not differ for LEAS Self [ $p=.604$ ], LEAS Other [ $p=.958$ ] and LEAS total [ $p=.389$ ].

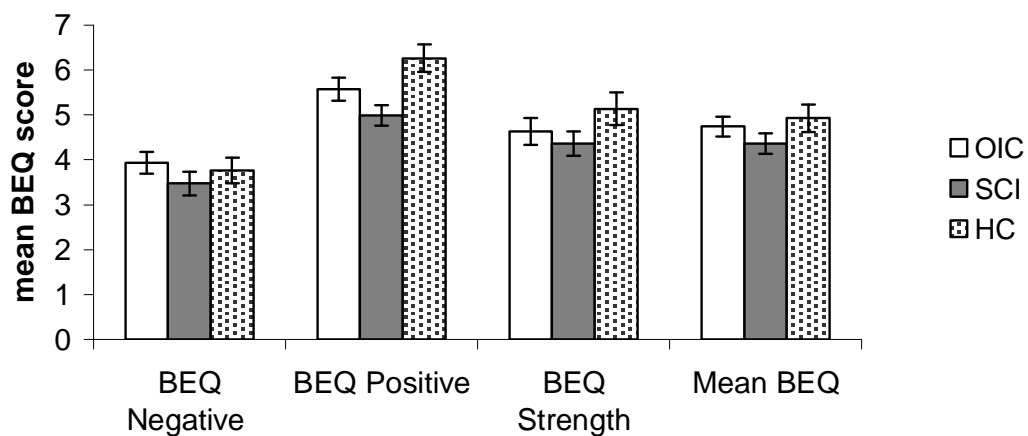
**Figure 3.3** LEAS scores for SCI, OIC & HC groups. Error bars represent  $\pm 1$  standard error of the mean.



### 3.3.3 Berkeley Expressivity Questionnaire (BEQ)

Internal reliability for the BEQ scores was calculated separately for BEQ positive, negative, strength and mean, using Cronbach's Alpha. For BEQ positive  $\alpha = .65$ ; for BEQ negative  $\alpha = .45$ ; for BEQ strength  $\alpha = .76$ ; for Mean BEQ  $\alpha = .85$ . A MANOVA with study group as the between subjects factor, and negative expressivity, positive expressivity and strength of expressivity as the within subjects factors was performed. The analysis revealed no difference between groups for Negative Expressivity [ $F(2,62)=.773, p=.467$ ], Positive Expressivity [ $F(2,62)=1.546, p=.222$ ] and Strength of Expressivity [ $F(2,62)=1.219, p=.303$ ] and Mean BEQ [ $F(2,62)=1.237, p=.298$ ].

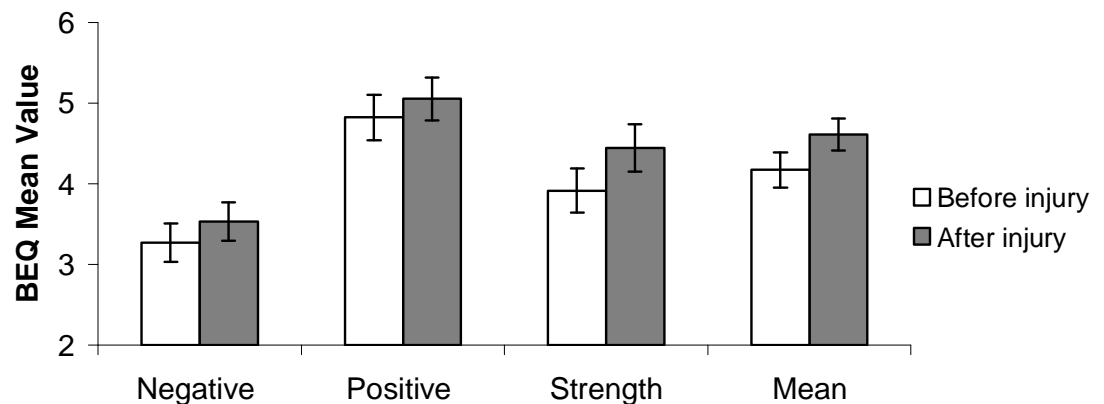
**Figure 3.4** BEQ scores for SCI, OIC & HC groups. Error bars represent  $\pm 1$  standard error of the mean.



3.3.4 Berkeley Expressivity questionnaire: Comparing expressivity before and after injury for patients with spinal injury

Internal reliability for the 'pre-injury' BEQ scores of SCI patients was calculated separately for BEQ positive, negative, strength and mean, using Cronbach's Alpha. For BEQ positive  $\alpha = .46$ ; for BEQ negative  $\alpha = .59$ ; for BEQ strength  $\alpha = .70$ ; for mean BEQ  $\alpha = .91$ . Paired sample tests were employed to compare BEQ scores before and after spinal injury. Patients scored significantly higher for BEQ Strength of emotional expressivity [ $p = .009$ ] and for Mean BEQ emotional expressivity [ $p = .001$ ] after spinal cord injury than before injury. No significant differences were found for BEQ Negative and Positive emotional expressivity when comparing before and after spinal injury; [ $p = .238$ ], [ $p = .169$ ] respectively.

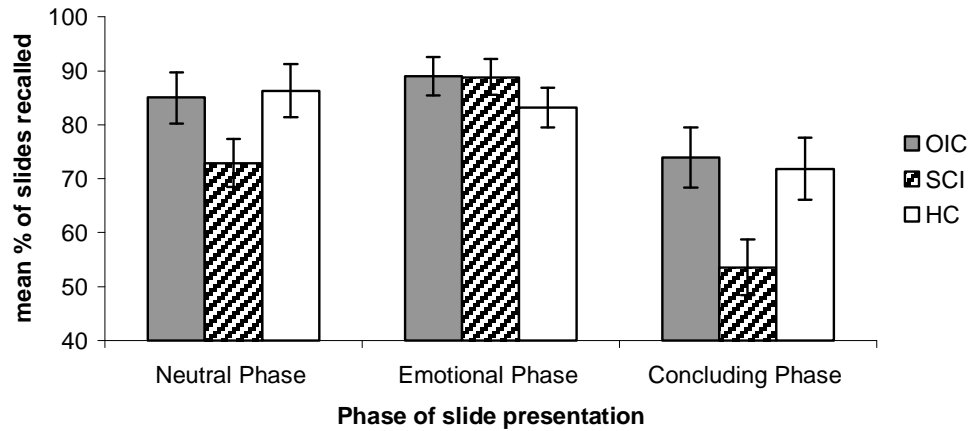
**Figure 3.5** Berkeley Emotional Expressivity: Comparing before & after spinal injury. Error bars represent +1/-1 standard error of the mean.



### *3.3.5 Free recall memory for slide presentation*

Repeated measures ANOVA was performed with study group as the between subjects factor, slide phase as the within subjects factor and free recall memory score as the dependent variable. Analysis revealed an almost main effect of study group [ $F(2,60)=2.853$ ,  $p=.066$ ] and a significant study group \* slide phase interaction [ $F(4,120)=3.328$ ,  $p=.013$ ]. The main effect of 'study group' and the almost 'study group' \* 'slide phase' interaction can be explained by Bonferroni pairwise comparisons, which reveal that SCI patients had significantly lower total free recall memory for the 3<sup>rd</sup> Concluding phase of the slide presentation than OICs [ $p=.017$ ] and HCs [ $p=.005$ ]. The three study groups free recall memory scores did not differ for Neutral phase or the Emotional phase of the slide presentation [all  $p>.124<1$ ]. See Figure 3.6.

**Figure 3.6** Free recall memory for slide presentation for SIC, OIC & HC groups. Error bars represent +1/-1 standard error of the mean.

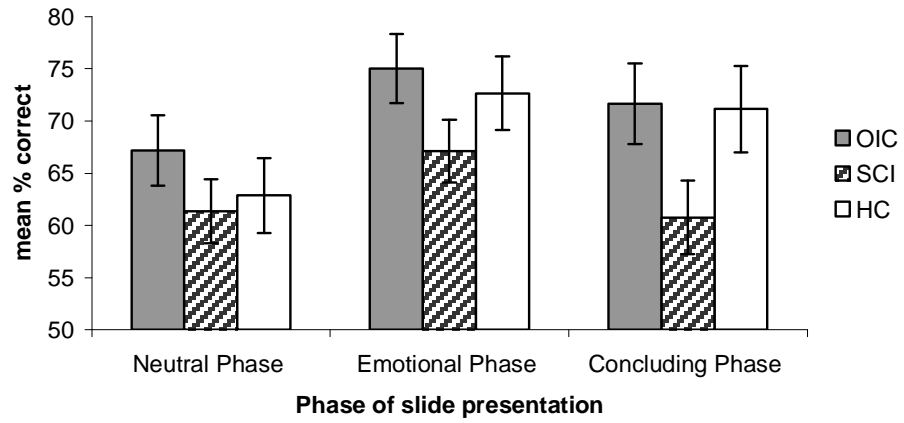


### 3.3.6 Recognition memory for slide presentation

Repeated measures ANOVA was performed with study group as the between subjects factor, slide phase as the within subjects factor and recognition memory score as the dependent variable. Analysis revealed no main effect of study group [ $F(2,57)= 1.954$ ,  $p=.151$ ] and no study group \* slide phase interaction [ $F(4,114)= 1.41$ ,  $p=.234$ ] on recognition memory scores.

**Figure 3.7** Recognition memory for slide presentation for SIC, OIC & HC groups.

Error bars represent +1/-1 standard error of the mean.



### 3.4 Discussion

#### 3.4.1 Emotional awareness & expressivity

The key comparison was between SCI and OIC patients and the analyses revealed no significant difference between these groups for LEAS Self, LEAS Other and LEAS Total. The HC group however, did score marginally significantly higher than the SCI for LEAS Self and significantly higher for LEAS Total. There were no differences between the HC and OIC groups for the 3 LEAS variables. The enhanced scores for HCs compared to SCI patients may be due to the fact that HC were recruited predominantly from the University of Stirling Psychology department and may be more comfortable with articulating emotional feelings, and also may have a wider range of vocabulary for emotional states. The fact that there was no difference between the key comparison group, the OICs, and the SCI group suggests that spinal-cord injury does *not* diminish awareness of emotion in self and others.

The three study groups did *not* differ in any of the BEQ measures. It is important to note that SCI patients reported *greater* Strength of emotional expressivity and greater Total BEQ *after* their spinal injury than before it. This finding directly contradicts the mainstream view advocated in the textbooks e.g. *An Introduction to Brain & Behaviour* (Kolb & Whishaw, 2005) and by the influential neurologist Antonio Damasio (1994; 1999).

#### 3.4.2 Memory



Results of the recognition memory test yielded no difference between the 3 study groups in memory for the slide presentation. The SCI group also did not show reduced recognition memory for the emotionally arousing phase of the slide presentation compared to the OIC and HC groups. Results of the free recall memory test revealed the SCI group did demonstrate reduced memory for 3<sup>rd</sup> Concluding phase of the slide presentation compared to OICs and HCs. However, this phase of the slide presentation does not depict any emotional scenes, these are all contained in 2<sup>nd</sup>, Emotional phase. Therefore, it can be concluded that SCI patients did *not* show reduced memory for emotional material compared to OICs and HCs.

### *3.4.3 Relating this study with previous research*

Previous research on the effects of SCI on emotion that have used qualitative methods or small samples sizes have often been overlooked by mainstream psychology and neuroscience. In light of the findings of this research it is important to reassess this research. For example, Dana (1921), in a study involving a single patient with a cervical lesion, failed to detect any changes in the intensity of emotional feelings one year after injury. Bermond, Nieuwenhuijse, Schuerman & Fasotti (1987) failed to show a reduction in mood state in 42 spinal cord lesioned patients. Jasnos & Hakmiller (1975) asked patients with lumbar, thoracic and cervical spinal cord damage to describe their most intense experience of anger, irritation or fear, since injury; and also to report their thoughts and feelings in response to slides depicting injured females. The authors found no difference in ratings of emotional arousal to the above tasks between the three spinal injury groups. Additionally, Chwalisz, Diener & Gallagher (1988) found spinal injured patients reported stronger fear in their lives presently compared with pre-injury.

Also, it is often overlooked that Hohmann (1966), in his still influential study, found that patients reported an increase in intensities of feelings of sentimentality, i.e. the propensity to cry easily in response to emotional situations. Additionally, Bermond, Nieuwenhuijse, Fasotti & Schuerman (1991), in a similar design employed by Hohmann (1966), interviewed 37 patients with spinal cord injury, asking them to compare the intensities of pre-injury emotional experiences with comparable experiences post injury. Patients also completed self rating scales concerning possible changes in emotional excitability. Patient's descriptions of their emotional experiences were categorised into somato-sensory emotional experiences (e.g. "My blood pressure went up, blood seemed to rush through my body") and mental emotional experiences (e.g. "I wanted to be comforted and helped by somebody"). The authors found that the intensities of the mental responses for fear and anger increased after spinal cord injury and the intensity of somatic responses for fear and anger remained the same. The results from the self-rating scales clearly showed that the majority of patients were convinced that their overall emotional excitability has either remained the same or increased since spinal injury. Similar to the results presented in this study, the spinal injured patients with the most reduced bodily feelings often reported feeling several emotions more intensely than before their injury. A majority of the spinal injured subjects in the low-feedback group (i.e. those that received the least bodily feedback due to the severity of their injury) reported increases in the intensity of feelings of love, joy, sentimentality, and sadness. Spinal injured patients also reported increases in the intensity of fear than those in other groups. Therefore, it is improbable if perception of autonomic arousal were critical to emotional experience that people would experience many emotions more strongly even after such feedback had been severely reduced.

More quantitative studies such as those by North & O' Carroll (2001), O' Carroll et al. (2003), Cobos et al. (2002) also suggest emotional functioning is not diminished in patients

with SCI. More recently Nicotra, Critchley, Mathias & Dolan (2005) used functional MRI (fMRI) to scan patients with SCI, as they participated in an aversive fear conditioning task. The patients viewed four angry faces, with one of the faces coupled with administration of a painful electric shock to the upper arm. When processing threatening stimuli, the authors reported that SCI patients have significantly weakened activity in subgenual and posterior cingulate cortices. However, the authors suggest that this reduced activity may cause a predisposition towards depressive symptoms and lack of emotional control due to maladaptive responses to aversive environmental stimuli, rather than evidence of reduced emotional intensity. This study also reported an enhancement of cortical and subcortical activity, in response to threatening stimuli, in SCI patients compared to controls. Dorsal anterior cingulate, PAG and regions of visual cortices displayed particular hyperactivity. Interestingly, the authors point out that the dorsal anterior cingulate region has been shown to be a region activated by emotional processing (Rainville 2002), and is active in conscious processing of emotional feelings. The authors propose that with reduced feedback of autonomic responses there may be compensatory activity in the anterior cingulate. These findings suggest that emotional intensity in SCI patients is not in fact dampened, and suggests that patients with SCI suffer loss of *control* over emotion with no evidence of a detriment in the *intensity* of experience of emotion. This finding, therefore, may offer an explanation for the finding in this thesis of an increase in emotional expressivity in patients with SCI after their injury compared to pre-injury.

### *3.4.3 Limitations of study*

A limitation of this study is that the HC participants were not well matched with SCI and OIC patients in terms of age and education. This discrepancy was due to the difficulty recruiting older participants within the University of Stirling population. However, age

and education was statistically controlled for in analyses comparing between the three participant groups. Additionally, the critical comparison was between the SCI and OIC groups, both these groups were closely matched in terms of having experienced a physical injury, having spent an equivalent amount of time in a hospital environment as well as being closely matched for age and education. Future research should also examine pre-injury emotional expressivity in OIC patients. This would permit a comparison between OIC and SCI groups for 'difference in emotional expressivity' between pre and post injury levels.

#### *3.4.4 Conclusion*

The LEAS and memory analyses and particularly the finding that SCI patients reported greater strength of emotional expressivity and greater mean emotional expressivity after SCI than before SCI directly contradicts the mainstream view point advocated by Damasio (1994; 1999) and Kolb & Whishaw (2005). However, it is consistent with previous research in the field, such as that of Bermond et al. (1987;1991) who reported that the intensities of the mental responses for fear and anger increased after SCI, and Jasnos & Hakmiller (1975) who found no difference in ratings of anger, irritation or fear in SCI patients from before and after injury. As Chwalisz et al. (1988) states; it is improbable if perception of autonomic arousal were critical to emotional experience that people would experience many emotions more strongly even after such feedback had been severely reduced. Also, as outlined by O' Carroll et al. (2003) other afferent feedback systems such as feedback via the vagus and other cranial nerves and hormonal feedback via the bloodstream may play a more important role in emotional expressivity and awareness, and memory for emotional events.

## **Chapter 4 Examining sex differences in arousal to, and memory for, offensive words relating to social status, physical attractiveness and sexual reputation**

### **Abstract**

#### *Objective:*

To investigate the following predictions:

1. Males will show greater arousal to, and enhanced memory for, threatening verbal words relating to 'social status'.
2. Females will show greater arousal to, and enhanced memory for, threatening verbal words relating to 'physical appearance' and 'sexual reputation'.
3. Self esteem is negatively correlated with recall of 'social status' threat words in males, and 'physical appearance' threat words in females.

#### *Method*

**Experiment 1:** Threatening verbal stimuli relating to 'social status', 'physical appearance', and 'sexual reputation' were presented to 49 males and 57 females within the context of an emotional Stroop task. Reaction time to each word category was recorded and analysed.

Memory for the words presented in the emotional Stroop task was also tested.

**Experiment 2:** Threatening verbal stimuli relating to 'social status', 'physical appearance', and 'sexual reputation' were presented to 42 males and 55 females within the context of a dot probe task. Reaction time to each word category was recorded and analysed. Memory for the words presented in the dot probe task was also tested.

#### *Results*

Results of reaction time data from both experiments failed to indicate a differential effect of sex on emotional arousal to the threatening verbal stimuli. Analysis of memory scores revealed females preferentially recalled words relating to 'physical appearance', with partial evidence males preferentially recognised words relating to 'social status'. Females also showed a significant negative correlation between self esteem and recognition memory of threatening words relating to 'physical appearance'.

### *Conclusion*

Results of both experiments provide evidence that memory and emotion do interact in an adaptive fashion. The limitations of both studies and the implications of the results for future research are also discussed.

## **4.1 Introduction**

As outlined in Chapter 1, emotions can be regarded as chemical and neural responses, fashioned by natural selection, that increase fitness in certain situations (Nesse 1990; Damasio 1994; 1999; Rolls 1990; 1999a; 2000). This view also outlines that the biological function of emotions is to increase the capability to deal with both aversive and agreeable stimuli present in the environment (Nesse 1990; Damasio 1999). Furthermore, each emotion should relate to a particular kind of adaptively significant situation that has occurred repeatedly during the course of evolution, and increase an individual's chances of coping with that type of situation successfully (Nesse, 1990; Damasio, 1999). Males and females have faced different obstacles to their reproductive success in the ancestral past, and thus, may have developed differing types of emotional states and reactions to deal with these different kinds of adaptively significant problems.

Analyses of the selective pressures that have faced males and females were discussed in Chapter 1. Theory was described that outlined how males are hypothesized to compete with one another for access to social status, whereas females are hypothesized to compete with one another to appear physically attractive and also to protect one's sexual reputation.

#### *4.1.2 Emotion and Memory*

As already outlined, and as stated by Hamann (2001), emotional arousal, whether of an agreeable or unpleasant nature, indicate stimuli that are likely to have both immediate and future importance to survival and reproductive success. Therefore, having greater memory for stimuli that elicit emotional arousal is adaptive as it ensures this information is available when needed in the future (McGaugh et al. 2000; Rolls 2000). A vast literature supports this showing individuals have enhanced memory for emotionally arousing compared to material of an emotionally neutral nature (Cahill & McGaugh 1998). The current study is interested in whether memory and emotion interact in an adaptive manner congruent with the hypothesized sex differences outlined above, i.e. that males will have greater memory than females for offensive stimuli suggesting they are of low status (or incapable of achieving high status) and females will have greater memory than males for offensive words suggesting they are physically unattractive and are sexually untrustworthy.

#### *4.2.5 Aims of this Chapter*

This chapter aims to assess sex differences in information processing of:

- a) negative verbal stimuli which are hypothesized to be more offensive to females than males i.e. words relating to ‘physical appearance’ and ‘sexual reputation’.
- b) negative verbal stimuli which are hypothesized to be more offensive to males than females i.e. words relating to ‘social status’.

The words will be presented in a context that will suggest they are referring to characteristics of the participant they are being presented to. In Experiment 1, the words

will be presented to participants via an emotional Stroop task, and in Experiment 2 words will be presented via a dot probe task. Both these tasks will allow the reaction time of participants to each word to be measured. Participants' memory of words presented to them in these tasks will be tested thirty minutes after task completion.

#### 4.2.6 *Predictions*

- 1 Males will show greater emotional arousal to, and enhanced memory for, words relating to threats to 'social status.
- 2 Females will show greater emotional arousal to, and enhanced memory for, words relating to threats to 'physical appearance' and 'sexual reputation'.

## 4.2 **Experiment 1 – Emotional Stroop**

### 4.2.1 **Introduction**

This study is interested in examining whether the above predictions are correct by presenting words to participants that will imply they are physically unattractive, sexually untrustworthy and of low social status (e.g. ugly, promiscuous and submissive, respectively). Words will be presented to participants via an emotional Stroop task. A review of the emotional Stroop literature by Williams, MacLeod & Mathews (1996) describes how the emotional Stroop task is a classical paradigm designed to detect biases in attention towards emotionally arousing words, and is a paradigm most frequently used to show attentional biases in anxiety patients. The task requires participants to name the font (ink) colour of words, ignoring the word itself. One of the fundamental findings in the emotional Stroop literature is that patients with anxiety disorders take longer to name the



colour of offensive or threatening words (Becker et al. 2001). The emotional Stroop task was deemed appropriate for the purpose of this study as much research employing this task reveals that the relatedness of words to a person's 'current' or 'personal' concern explains the findings of colour naming interference for emotional stimuli (i.e. taking longer to name the font colour of emotional stimuli) more so than the general emotionality of words (Williams, Mathews & MacLeod 1996). For example, Lavy & van den Hout (1993) found participants who had fasted for twenty four hours showed a colour naming delay for words that were related to food. Additionally, Mathews & Klug (1993) tested patients with general anxiety disorder (GAD), panic disorder, social phobia and controls with words differing in their emotional valence and degree of relatedness to anxiety. The results revealed that colour naming interference was due to the relatedness of words to anxiety rather than the emotional valence of the words.

This study hypothesises that males and females differ in terms of personal concern, with males more concerned with social status, and females with physical appearance and sexual reputation. Considering the emotional Stroop interference effect seems to be the result of colour naming interference of emotionally relevant words it seems ideally suited for this study.

#### *4.2.8 Potentially confounding variables*

The emotional Stroop literature reveals levels of anxiety and depression affect performance, with research showing highly anxious individuals and depressed individuals showing increased emotional reaction to 'threat' stimuli (Williams, Mathews & MacLeod 1996). Therefore, study participants will be asked to complete the Spielberger Trait and State anxiety questionnaires as well the depression component of the HADS, in order to

control for the possible effects of anxiety and depression on emotional Stroop performance.

## **4.2.2 Methods**

### *4.2.2.1 Participants*

Power analysis was used to determine the appropriate sample for this study. An effect size of 0.4 was entered into a Power analysis software program (GPower™), in which Alpha was set at .05, power at .80, and number of groups set at 2. This program computed a total sample size of 52 participants as being appropriate for the 2 groups in this experiment. To ensure increased statistical power, one hundred and six participants (49 males & 57 females) from the University of Stirling student population were recruited to take part in this study. Participants were recruited using £5 monetary reward or course credit as incentive for taking part. The average age of participants was 23.62 years (S.D. =6.8 years; Range =17-53 years). In line with previous research (e.g. Wenzel & Holt 1999), exclusion criteria for all participants in this study were: current or previous history of major depression, mania, psychosis, and current panic disorders (agoraphobia, social phobia, generalised anxiety disorder, and obsessive compulsive disorder).

### *4.2.2.2 Ethical approval*

Ethical approval to carry out this study was granted by the University of Stirling Department of Psychology Ethics committee. An application with a detailed description of the study was submitted to this committee detailing the full aims and methodology of the

proposed research. This committee made their decision to approve this study after careful analysis of this application.

#### 4.2.2.3 Emotional Stroop

The emotional Stroop (ES) task was presented on a laptop computer using e-prime™ software to create the task. The words used for the ES task were chosen based on the hypothesized sex differences previously outlined. The three categories of words are as follows:

- a) Five words were chosen that related to physical unattractiveness and sexual reputation: ‘ugly’, ‘fat’, ‘flabby’, ‘promiscuous’, and ‘unfaithful’. These words were categorized as Female Negative (FN) words
- b) Five words were chosen that related to social status: ‘weak’, ‘submissive’, ‘pathetic’, ‘subordinate’, ‘cowardly’. The words were categorized as Male Negative (MN) words.
- c) Five words were also chosen of a negative nature but which were gender neutral: ‘selfish’, ‘dishonest’, ‘arrogant’, ‘sly’, ‘stupid’. These words were categorized as General Negative (GN) words. (See Appendix 13).

There was no *a priori* reason to expect males or females to be differentially offended by GN words. In her construction of the Bem sex role inventory, Bem (1974) found that the personality characteristics that words in the GN category related to, were gender neutral, i.e. not differentially rated as more desirable for men than women. Thirty control words of a neutral nature and fifteen words of a positive emotional nature (e.g. honest, generous) were also included in the task. Positive words were included as fillers so that participants

would not become aware of the purpose of the Stroop task, i.e. that the experimenter was interested in their reaction to offensive emotional stimuli. If participants were aware that this was the purpose of the task it is likely a Stroop interference effect would not be found as participants may deliberately increase their concentration to name the font colour of offensive stimuli. It is this tactic of increased 'effort level' in colour naming of words that is believed to be responsible for the null findings in emotional Stroop research involving nonclinical samples (Williams, Mathews & MacLeod 1996). The reaction times to positive emotional stimuli were not of interest to this study and were excluded from future analysis. Each of the word categories in this experiment were matched for length, and frequency of occurrence in the English language using Kilgariff's (1997) frequency values (see Appendix 13).

Immediately before the Stroop task, participants were informed that "a word would appear on the screen in one of 4 colours (red, green, blue or yellow). Your task is to confirm what colour the word appears in by pressing the appropriate button below as soon as the word appears" (there was a choice of a red, green, blue and yellow buttons to press).

Participants were instructed that the words that appeared in the task "are adjectives that could be used to describe material things in the world, and some of them could be used to describe you". This was to implant the idea that the negative words that appeared in the task were referring to the participants themselves. Each of the 60 words was displayed, one at a time, in one of 4 coloured fonts: red, green, blue or yellow. Each word was presented for 4 seconds duration, this time duration was chosen on the basis of previous research involving the emotional Stroop (Williams, Mathews & MacLeod 1996). The E-prime™ software was programmed to display each of the 60 words once, and in a random order. Also, the colour each word appeared in was randomised for each trial. See appendix 13 for full list of all words used in emotional Stroop task. Participants were

given 15 'practice trials' to familiarise themselves with the task before beginning the task proper.

#### 4.2.2.4 *Rating offensiveness of words employed in emotional Stroop task*

In order to validate that FN words are actually more offensive to females than males, that MN words are more offensive to males than females, and that GN are not differentially offensive to males or females, the 3 different word categories were rated for offensiveness by an independent sample of males and females.

These three categories of words were rated by an independent sample of 97 participants from the University of Stirling student population (35 Males and 62 females). Males and females in this sample were matched for age, with the mean age of males in this sample: 22.06 (SD=5.434; Range= 17-41 years), and the mean age of females in this sample: 22.32 (SD=6.317; Range= 18-48 years). This sample was asked to rate on a scale of 1 to 10 (1 = 'not offended at all', and 10 = 'very offended'):

- a) How offended would you be if the following words were used to describe you?
- b) How offended would other females be if the following words were used to describe them?
- c) How offended would other males be if the following words were used to describe them?

The results of this rating experiment are displayed in the results section.

#### *4.2.2.4.1 Predictions for ratings of offensiveness*

Based on the theory outlined previously it is expected that males will rate MN words as more offensive to ‘themselves’ and more offensive for ‘other males’. Females, alternatively, are predicted to rate FN words as more offensive to ‘themselves’ and more offensive for ‘other females’. No sex difference in offensiveness ratings are predicted for GN words.

#### *4.2.2.5 Colour blindness test*

The Ishihara test for colour blindness (Ishihara 1917) was administered to participants prior to starting the emotional Stroop task. This task consists of series of pictures each displaying a pattern of dots revealing a number. Individuals who are ‘red-green’ colour blind see different numbers than those with normal colour vision. This task was administered on a laptop computer using E-prime™ software. No individuals needed to be excluded on the basis of failing the colour blindness test.

#### *4.2.2.6 Hospital Anxiety and Depression Scale (HADS)*

The depression dimension of the HADS was used to measure levels of depression in the participants. See Chapter 3 *Methods* for full description of HADS.

#### *4.2.2.7 Spielberger State anxiety questionnaire*

The Spielberger State anxiety questionnaire was used to measure levels of state anxiety in the participants. See Chapter 2 Experiment 2 *Methods* for full description.

#### 4.2.2.8 *Spielberger Trait Anxiety questionnaire*

The Spielberger Trait Anxiety questionnaire was used to measure levels of trait anxiety in the participants. See Chapter 2 Experiment 2 *Methods* for full description.

#### 4.2.2.9 *Procedure*

Participants were not informed they would receive memory tests on the words appearing in the emotional Stroop task. Instead they were instructed that “certain aspects of the procedure will not be explained to you now as it might bias the results of the study, but they are only minor aspects and you will receive a full debriefing at the end of the study”. Participants then signed a consent form before completed the Ishihara colour blindness test. Participants then completed the emotional Stroop task. Following the Stroop task, participants completed series of questionnaires presented online: the Spielberger state anxiety questionnaire, the Spielberger trait anxiety questionnaire, and the HADS. After completing the questionnaires, participants were then informed that they would receive a surprise free recall memory test on the words that appeared in the emotional Stroop task (excluding words that appeared in the practice phase). Participants were provided with a blank sheet of paper to write down as many words as they could remember. When participants were unable to remember any more words they were given a surprise recognition memory test. The test contained a list of all the words that appeared in the emotional Stroop task plus 60 extra ‘lures’ (i.e. words that were similar in nature to the words appearing in the emotional Stroop task), matched for length and frequency of occurrence in the English language. These words were listed in a randomised order on a sheet of paper. The order of words in the task was randomised for each participant using

the software program Word Shuffle™ (from www.fellz.com 2002). Participants were asked to circle any words they think they might recognise from the emotional Stroop task (excluding words that appeared in the practice phase of the emotional Stroop task). Participants were then fully debriefed as to the full aims and rationales of the study.

### 4.2.3 Results

#### 4.2.3.1 Ratings of verbal stimuli

*The higher the rating scale score, the more offensive the words were rated. The lower the rating scale score the less offensive the words were rated.*

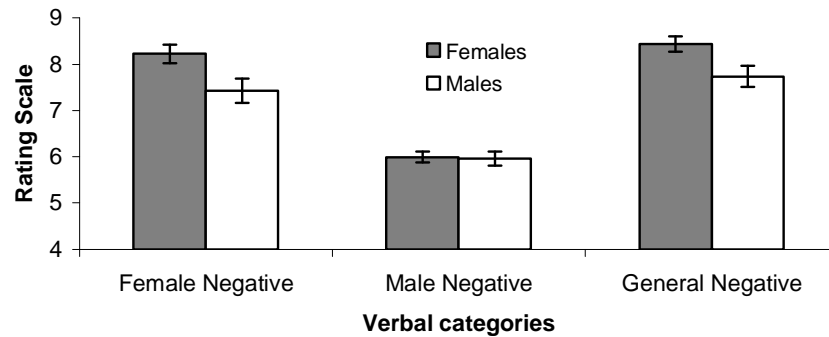
*(a) How offended would you be if the following words were used to describe you?*

Inter rater reliability for these word ratings were calculated for each word category (i.e. FN, MN and GN words) separately for females and for males using Cronbach's Alpha. For inter rater reliability for FN words,  $\alpha = .53$  for female raters,  $\alpha = .82$  for male raters. For MN words:  $\alpha = .61$  for female raters, and  $\alpha = .05$  for male raters. For GN words:  $\alpha = .73$  for female raters, and  $\alpha = .62$  for male raters. A repeated measures ANOVA was performed on rating scale scores, with 'sex' as the between subjects factor, 'word category' as the within subjects factor, and rating scale score as the dependent variable. The analysis revealed a significant between subjects effect of 'sex' [ $F(1,95)=8.741$ ,  $p=.004$ ], with females being generally more offended than males (collapsing across word categories). There was a significant within-subjects main effect of 'word category' [ $F(2,190)=102.023$ ,  $p<.001$ ], with Bonferroni pairwise comparisons revealing FN and GN more offensive than MN words: [ $p<.001$ ] & [ $p<.001$ ] respectively.



The analysis also revealed a significant ‘sex’ \* ‘word category’ interaction [ $F(2,190)=3.43$ ,  $p=.034$ ]. Post hoc tests (one way ANOVAs) revealed this was due to females being significantly more offended by the FN [ $F(1,95)=7.257$ ,  $p=.008$ ] and GN [ $F(1,95)=7.472$ ,  $p=.007$ ] word categories than males but not differing from males for the MN word category [ $F(1,95)=.3$ ,  $p=.585$ ]. See Figure 4.1

**Figure 4.1** Self rating of negative verbal stimuli. Error bars represent +1/-1 standard error of the mean.



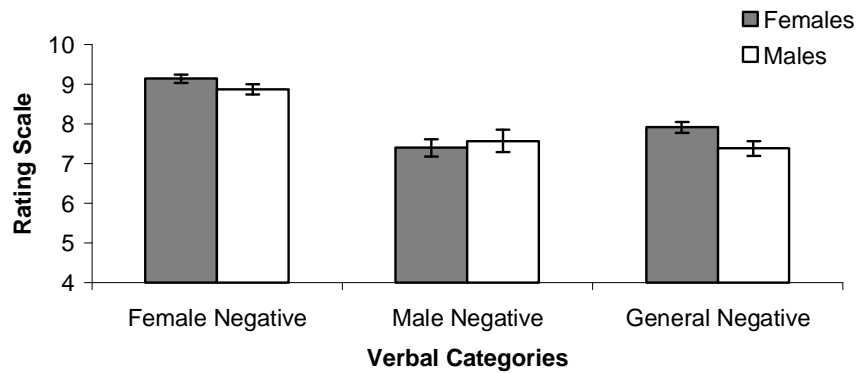
*(b) How offended would other people, who are female, be if the following words were used to describe them?*

Inter rater reliability for these word ratings were calculated for each word category (i.e. FN, MN and GN words) separately for females and for males using Cronbach’s Alpha. For Inter rater reliability for FN words,  $\alpha = .61$  for female raters, and  $\alpha = .43$  for male raters. For MN words:  $\alpha = .87$  for female raters, and  $\alpha = .81$  for male raters. For GN words:  $\alpha = .48$  for female raters, and  $\alpha = .24$  for male raters. A repeated measures ANOVA was performed on rating scale scores, with ‘sex’ as the between subjects factor, ‘word category’ as the within subjects factor and rating scale score for ‘other females’ as the

dependent variable. The analysis revealed no significant between subjects effect of 'sex' [F(1,95)=1.906, p=.171] on offensiveness scores. There was a significant within subjects effect of 'word category' [F(2,190)=78.463, p<.001], with Bonferroni pairwise comparisons revealing FN words would be more offensive to 'other females' than both MN and GN words: [p<.001] & [p<.001] respectively.

The analysis also revealed a significant 'sex' \* 'word category' interaction [F(2,190)=3.446, p=.034]. A one way ANOVA revealed this was due to female ratings for the FN words being marginally significantly higher [F(1,95)=3.49, p=.065] and significantly higher for GN [F(1,95)=7.472, p=.007] words than male ratings but with no difference in male and female ratings for the MN word category [F(1,95)=.3, p=.585]. See Figure 4.2.

**Figure 4.2** Ratings of how offensive the stimuli would be to other people, who are female. Error bars represent +1/-1 standard error of the mean.

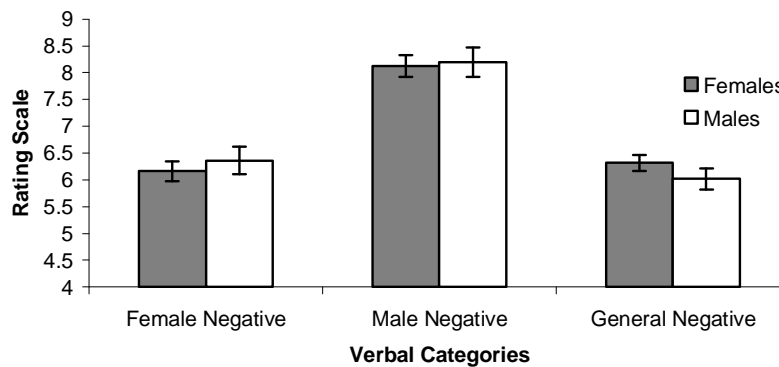


*(c) How offended would other people, who are male, be if the following words were used to describe them?*

Inter rater reliability for these word ratings were calculated for each word category (i.e. FN, MN and GN words) separately for females and for males using Cronbach's Alpha. For Inter rater reliability for FN words,  $\alpha = .67$  for female raters, and  $\alpha = .76$  for male raters. For MN words:  $\alpha = .84$  for female raters, and  $\alpha = .73$  for male raters. For GN words:  $\alpha = .25$  for female raters, and  $\alpha = .31$  for male raters. A repeated measures ANOVA was performed on rating scale scores, with 'sex' as the between subjects factor, 'word category' as the within subjects factor and rating scale score for 'other males' as the dependent variable. The analysis revealed no significant between subjects effect of 'sex' [ $F(1,95) = .023$ ,  $p = .881$ ] on offensiveness scores. There was a significant within subjects effect of 'word category' [ $F(2,190) = 103.961$ ,  $p < .001$ ], with Bonferroni pairwise comparisons revealing MN would be more offensive to 'other males' than both FN and GN words: [ $p < .001$ ] & [ $p < .001$ ] respectively.

The analysis revealed no significant 'sex' \* 'word category' interaction [ $F(2,190) = 2.515$ ,  $p = .084$ ]. See Figure 4.3.

**Figure 4.3** Ratings of how offensive the stimuli would be to other people, who are male. Error bars represent +1/-1 standard error of the mean.



#### 4.2.3.1.1 *Summary of ratings of word categories*

Thus, the analyses of the ratings of the verbal stimuli indicate that females are more offended by FN words than males and they believe ‘other’ females are also more offended by these words than males. The results did not suggest that males found MN words more offensive than females when they were asked about how offensive they would find MN words personally. However, the results indicated that males believe ‘other’ males would find these words more offensive than females. This suggests that males recognise that these types of words are generally offensive for males but that perhaps are reluctant to reveal that they find these words personally offensive.

#### 4.2.3.2 *Potentially confounding variables in the emotional Stroop*

A series of one way ANOVAs with ‘sex’ as the between subjects factor was performed on age, trait anxiety, state anxiety and depression scores. The results are displayed in Table 4.1 below and show that age and HADS depression differ significantly between the groups. Internal reliability for State anxiety, Trait anxiety and HADS depression was determined

using Cronbach's Alpha. For State anxiety  $\alpha = .84$ ; for Trait anxiety  $\alpha = .89$ ; for HADS depression = .78.

**Table 4.1.** Analysis of potentially confounding variables.

	Females (N= 57)		Males (N= 49)		F value	P value
	Mean	SD	Mean	SD		
Age	21.72	5.744	25.9	7.318	10.728	.001**
Trait A	40.02	10.442	41.94	9.479	.951	.332
State A	34.52	9.953	38.10	8.702	3.807	.054
HADS D	1.77	1.870	4.00	2.482	20.099	.001**

**Key.** SD= Standard deviation. Trait A = Trait anxiety, State A = State anxiety. HADS D = HADS depression.

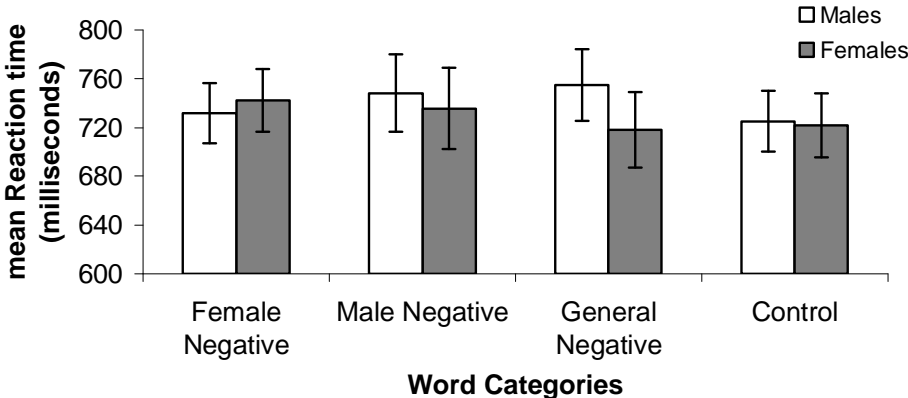
As a result of the between group differences for age, state anxiety and HADS depression, all future analysis comparing reaction time and memory performance between males and females will have these variables entered as covariates.

#### 4.2.3.3 Emotional Stroop reaction times

Based on previous research employing the emotional Stroop task (Egloff & Hock 2003) trials with reaction time (RT) less than 150ms or greater than 1200 ms were excluded from the analysis (1.5% of trials). In order to assess whether males and females differed in their baseline RT scores, a one way ANOVA on RT for Control words with 'sex' as the between subjects factor was performed. The analysis revealed no difference between males and females in baseline RT [ $F(1,101)=.506, p=.479$ ] (see Figure 4.4).

A repeated measures ANOVA was performed on reaction time (RT) scores, with 'sex' as the between subjects factor, 'word category' as the within subjects factor and RT as the dependent variable. The analysis revealed no between subjects effect of 'sex' on RT scores [ $F(1,101)=.688, p=.409$ ]. There was also no within subjects effect of word category on RT scores [ $F(3,303)=2.03, p=.114$ ]. There was also no 'sex' \* 'word category' interaction on RT scores [ $F(1,101)=.023, p=.880$ ]. See Figure 4.4.

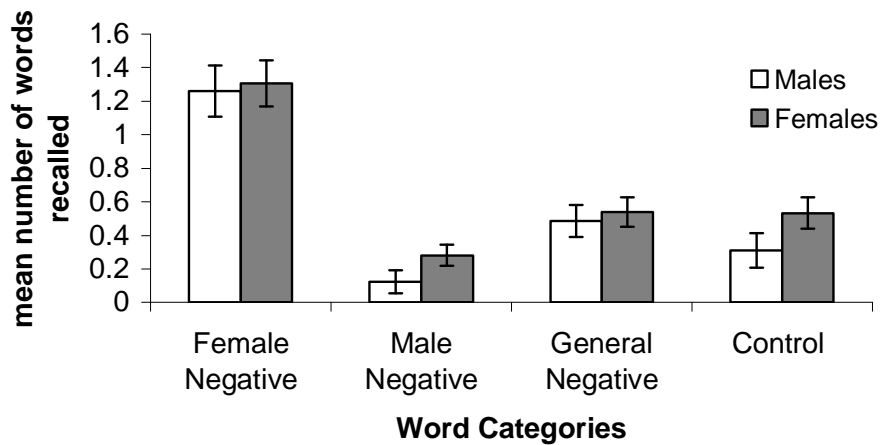
**Figure 4.4** Reaction time to verbal stimuli. Error bars represent +1/-1 standard error of the mean.



#### 4.2.3.4 Free Recall Memory

A repeated measures ANOVA was performed on free recall memory scores, with 'sex' as the between subjects factor, 'word category' as the within subjects factor and free recall memory as the dependent variable. The analysis revealed no between subjects effect of 'sex' on free recall memory scores [ $F(1,100)=1.397, p=.24$ ]. There was a within subjects effect of 'word category' on free recall scores [ $F(3,300)=7.814, p<.001$ ]. Bonferroni pairwise comparisons revealed greater memory for FN words than for MN [ $p<.001$ ], GN [ $p<.001$ ], and Control words [ $p<.001$ ], and greater memory for GN [ $p<.001$ ] and Control words [ $p=.00$ ] than MN words. There was, however, no sex \* 'word category' interaction on free recall memory scores [ $F(3,300)=.336, p=.8$ ].

**Figure 4.5** Free recall memory for verbal stimuli. Error bars represent +1/-1 standard error of the mean.



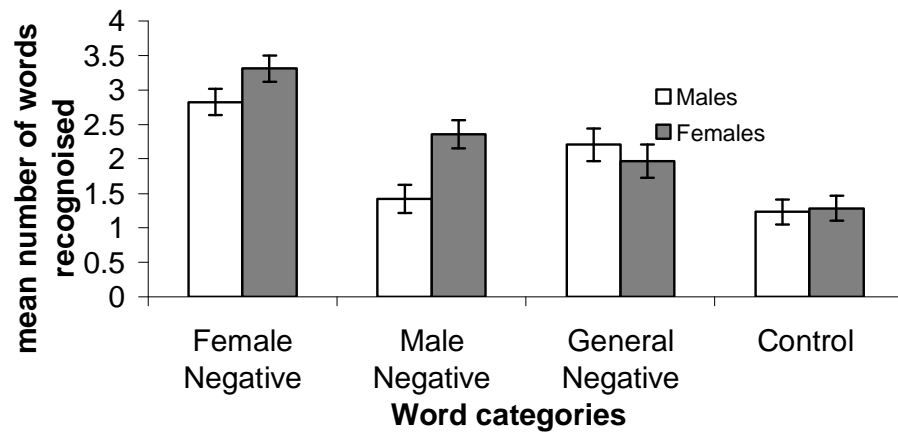
#### 4.2.3.5 *Recognition Memory*

A repeated measures ANOVA was performed on recognition memory scores, with 'sex' as the between subjects factor, 'word category' as the within subjects factor and recognition memory as the dependent variable. The analysis revealed no between subjects effect of 'sex' on recognition memory scores [ $F(1,96)=1.955$ ,  $p=.165$ ]. There was a significant within subjects effect of 'word category' on recognition memory scores [ $F(3,288)=4.351$ ,  $p=.005$ ]. Bonferroni pairwise comparisons revealed significantly greater memory for FN words than all other word categories [all  $p<.001$ ]. Also, memory for MN and GN words was greater than memory for Control words.

There was, a significant 'sex' \* 'word category' interaction on recognition memory scores [ $F(3,288)=4.251$ ,  $p=.006$ ]. Univariate ANOVAs revealed the interaction was due to marginally significantly greater memory for FN [ $F(4,96)=2.776$ ,  $p=.099$ ] and significantly greater memory for MN [ $F(4,96)=9.559$ ,  $p=.003$ ] words for females than males, but (non-significantly) greater memory for GN words for males than females [ $F(4,96)=.436$ ,  $p=.511$ ]. See Figure 4.6.



**Figure 4.6** Recognition memory for verbal stimuli. Error bars represent +1/-1 standard error of the mean.



#### 4.2.4 Discussion - Experiment 1

##### 4.2.4.1 Ratings of verbal stimuli

The offensiveness ratings of the verbal stimuli used in the emotional Stroop task yielded some interesting results. When asked to rate ‘how offended would you be if the following words were used to describe you?’ females rated the FN and GN words as more offensive to ‘themselves’ than did males. Females also rated FN words as more offensive to ‘themselves’ than MN words, but only as equally offensive as GN words. However, it was not predicted that females would rate the GN words as more offensive than males. This finding may be due to males being less likely to admit taking offence to an insult. The fact that females rated FN and GN words as equally offensive was also not predicted, however an explanation for this is proffered below.

Contrary to the theory outlined in the introduction, males found the GN and FN words more offensive ‘to themselves’ than the MN words. When asked to rate ‘how offended

would other females be if the following words were used to describe them?’ females also deemed FN and GN words as more offensive to ‘other females’ than did males. However, both males and females rated the FN words as being more offensive to ‘other females’ than the GN or MN words. So although females do not consider FN words to be more offensive to ‘themselves’ than GN words, they do expect ‘other females’ to be more offended by FN than GN words. This finding is in line with the outlined hypotheses. A similar finding was revealed when participants were asked to rate ‘how offended would other males be if the following words were used to describe them?’ Both males and females deemed the MN words would be more offensive to ‘other males’ than either the FN or GN words. Therefore, males rate MN words as not being particularly offensive to them, but likely to be very offensive to other males. These contradictions in the findings may be due to a self-serving bias on the behalf of males and females; not wanting to admit to themselves that personality traits associated with social status (for males) and ‘physical appearance’ and ‘sexual reputation’ (for females) are important to them but nevertheless acknowledging that they are likely to be important to ‘other males’ and ‘other females’ respectively.

Therefore, taken as a whole, these findings validate the use of the verbal stimuli used in Experiment 1. They provide evidence to support the prediction that females are more likely than males to be offended by words relating to ‘physical appearance’ and ‘sexual reputation’, and thus show greater emotional arousal in response to these words, and consequently have enhanced memory for these words. Similarly, the results provide evidence that males will be more offended by words relating to ‘social status’, and thus show greater emotional arousal in response to these words and enhanced memory for these words.

#### *4.2.4.2 Emotional Stroop reaction times*

The emotional Stroop reaction time data did not yield results in support of the outlined hypotheses. There was no difference between males and females in RT for each of the three threatening verbal stimuli categories. Additionally, females did not show delayed RT for FN compared to MN words, similarly, males did not show delayed RT for MN compared to FN words. A possible short coming of this study is that the emotional Stroop task may be too crude to detect differences in emotional reaction to coloured 'threat' words within a non-clinical population. The emotional Stroop literature suggests that this may be the case. Martin, Williams & Clark (1991) failed to find a difference in emotional Stroop interference for threat words (e.g. pathetic & disease) between participants with high trait anxiety, medium trait anxiety and low trait anxiety. The authors also compared a group clinically diagnosed as anxious with a nonclinical group matched for trait anxiety and found a Stroop interference effect for the clinical group but not for the high- trait anxiety group. Mathews & MacLeod (1994) suggest that nonclinical participants may be able to override the tendency to be distracted by emotional words. Williams, Mathews & MacLeod (1996) suggest they achieve this by increasing 'effort' expended in naming the colour. Due to the possible limitation of using the emotional Stroop task to detect emotional arousal within a nonclinical population, a dot probe (also called attentional probe) task was employed in Experiment 2 to detect emotional arousal to threatening verbal stimuli.

#### 4.2.4.3 *Free recall and recognition memory*

The results of the free recall memory test did not support the hypotheses outlined in this study. Both males and females showed enhanced memory for FN words compared to all other word categories. In fact, memory for MN words fell below that of memory for control words for both males and females.

Recognition memory scores showed a 'sex' by 'word category' interaction. Males and females did not differ in their memory for Control and GN word categories, but females had marginally significantly greater memory for FN words than males and significantly greater memory for MN words than males. Therefore, the recognition memory data may suggest that females were more emotionally aroused by offensive words relating to 'physical appearance' and 'sexual reputation' than males, with this increased arousal enhancing memory of these words. However, the enhanced memory for females for offensive words relating to social status is not easily reconcilable with the hypotheses outlined in this study.

Interestingly, male free recall and recognition memory for MN words is surprisingly low. The free recall memory test showed females with significantly greater memory for MN words than males, and the recognition memory test revealed male memory for MN words was similar to memory for control words. Considering an independent sample of males rated MN words as being less offensive than FN or GN words for 'themselves' but more offensive than FN and MN words for 'other males', perhaps there was a conscious or unconscious effort by males to not want to 'reveal' that these words caused them offence by recalling them in the memory tests. The free recall and recognition memory tests were pen and paper tests and thus there may have been an inclination to 'hide' from the

examiner words that caused offence. An 'online' memory test on a computer in which participants could place a tick beside the words they recognised and 'submit' the answers may feel more anonymous to participants than a pencil and paper test. This possibility is taken into account in the design of Experiment 2.

Although females showed marginally significantly greater memory for FN words than males in the recognition memory task, one cannot deduce whether this is due to enhanced memory for words relating to 'physical appearance' or words relating to 'sexual reputation'. It may be the case the females are very threatened by the 'physical appearance' words but not so much by the 'sexual reputation' words and that this effect is being masked by grouping the two separate types of words into one FN category. This shortcoming is also addressed in Experiment 2.

### **4.3 Experiment 2 - Dot probe task**

#### **4.3.1 Introduction**

As outlined above, the emotional Stroop failed to detect any differential emotional arousal caused by the verbal stimuli. Therefore, it was decided that the dot probe (or attentional probe) task would be employed in a second study to attempt to address this problem. The dot probe task involves the simultaneous presentation of a 'threat' and 'neutral' word on a computer screen. Both words disappear (typically after 500 milliseconds) and a dot appears in the previous position of one of the words. As soon as participants see the dot they press a button to indicate the position of the dot. Fast reaction times to dots that appear in the position of threat words, and slow reaction times to dots that appear in the position of neutral words indicate attentional bias and thus emotional arousal to threat

words (MacLeod et al. 1986; Egloff & Hock 2003). The dot probe task has had success detecting differential attention bias to threat words in nonclinical samples (e.g. Lipp & Derakshan 2005; Koster et al. 2004; Mogg et al. 2000). Lipp & Derakshan (2005), for example, found attentional bias for probes appearing immediately after the presentation of images of threatening animals, in a nonclinical sample. Koster et al. (2004) found a sample of university students showed differential attentional bias to threatening stimuli, with the authors concluding the mechanism responsible for this attentional bias was a 'difficulty to disengage' from threatening material. Similar to the emotional Stroop task, performance on the dot probe task is affected by levels of anxiety (e.g. Mathews & MacLeod 1994), and depression (e.g. Gotlib et al. 2004); with high anxious and depressed individuals showing attentional bias towards threat words. Therefore, the same measures employed in Experiment 1 to control for the effects of anxiety and depression on Stroop performance were also used here to control for the effects of anxiety and depression on attentional bias to threat words in the probe task in Experiment 2.

As previously mentioned, the grouping of 'physical appearance' and 'sexual reputation' threat words into one FN category in Experiment 1 may have masked the effect of either one of these sub-categories on RT and memory scores. Therefore, to address this problem, 4 word categories of critical interest were created for Experiment 2: 1) 'physical appearance' words, 2) 'sexual reputation' words, 3) 'social status' words, and 4) 'general negative' words.

The possibility that males may be reluctant to 'reveal' remembering offensive words relating to status was also addressed for Experiment 2. The pencil and paper recognition memory test of Experiment 1 was replaced with a more anonymous 'online' format, in which participants placed a tick besides the words they recognised from that task then

'submitted' their answers, rather than hand back the sheet to the experimenter. However, the format of the free recall memory test remained the same as is in Experiment 1.

Experiment 2 also aims to investigate how 'self-esteem' may be related to dot probe and memory performance for the 4 word categories. The evolutionary psychiatrists Stevens & Price (2000) argue that in humans, our perception of our own 'mate value' (how desirable we are as mates to the opposite sex) plays an essential role in the formation of our self-esteem. The authors state how in order to assess our own 'mate value' we compare ourselves to others in terms of physical attractiveness, size, social status, our network of friends etc. For males more than females, social status is a very important determinant of mate value, with high status males being more attractive to females than lower status males. For females, physical attractiveness is the prime determinant of 'mate value', with physically attractive females being more sought after by males than females considered less physically attractive. If perceiving oneself as having low self esteem is linked with low mate value, as outlined above, then one would expect males with low self esteem to be more offended, and thus more emotionally aroused by 'social status' threat words, and consequently have greater memory for such words. Comparably, one would expect females with low self-esteem to be more emotionally aroused and thus have greater memory for 'physical appearance' threat words.

#### *4.3.1.1 Predictions for Experiment 2*

- 1) Males will have greater emotional arousal to, and enhanced memory for, words relating to threats to 'social status'.
- 2) Females will have greater emotional arousal to, and enhanced memory for, words relating to threats to 'physical appearance' and 'sexual reputation'.

- 3) Self esteem will negatively correlate with emotional arousal to, and memory performance for, 'social status' threat words for males.
- 4) Self esteem will negatively correlate with emotional arousal to, and memory performance for, 'physical appearance' threat words for females.

## **4.3.2 Methods**

### *4.3.2.1 Participants*

Power analysis was used to determine the appropriate sample for this study. An effect size of .4 entered into a Power analysis software program (GPower™), in which Alpha was set at .05, power at .80, and number of groups at 4. This program computed a total sample size of 76 participants as being appropriate for the 4 groups in this experiment. To ensure increased statistical power, ninety seven individuals (55 females, 42 males) were recruited to take part in this study. Eighty six were recruited from the University of Stirling student population, using monetary reward or allocation of course credits as incentive to take part. Eleven participants were recruited from the Glasgow Science Centre. The mean age of males in the study was 20.07 years ( $SD=2.503$ ; Range = 17-30 years), the mean age of females was 23.85 years ( $SD=7.63$ ; Range= 17-46 years). The sample size chosen for this study was based on similar sample sizes used in previous studies of this nature (e.g. Egloff & Hock 2003). In line with previous research (e.g. Wenzel & Holt 1999), exclusion criteria for all participants in this study were: current or previous history of major depression, mania, psychosis, and current panic disorders (agoraphobia, social phobia, generalised anxiety disorder, and obsessive compulsive disorder).



#### 4.3.2.2 *Spielberger State anxiety questionnaire*

See Chapter 2, experiment 2 Methods for full description.

#### 4.3.2.3 *Spielberger Trait Anxiety questionnaire*

See Chapter 2, experiment 2 Methods for full description.

#### 4.3.2.3 Hospital Anxiety and Depression Scale (*HADS*)

See Chapter 2, experiment 1 Methods for full description.

#### 4.3.2.4 *Rosenberg Self Esteem scale*

The Rosenberg self esteem scale (RSE) is one of the most extensively used measures of self esteem in Health and Clinical psychology (Rosenberg 1965; Blascovich & Tomaka 1993). The RSE consists of 10 items, 5 of which are expressions of positive self-esteem (1,3,4,7,10) and five of negative self esteem (2,5,6,8,9). Items are scored from 1 to 4 with an RSE score derived by summing each item to give a maximum of 40 or a minimum of 10. High scores indicate *low* self esteem. A copy is reproduced in Appendix 15

#### 4.3.2.5 *Dot Probe*

The dot probe task was created using E-prime™ experiment generating software, and was presented on a laptop computer. Four ‘threatening’ word categories were created.

- a) Physical appearance (PA) words, consisting of: ‘ugly’, ‘fat’, ‘flabby’, ‘unattractive’, ‘chubby’.
- b) Sexual reputation (SR) words, consisting of: ‘promiscuous’, ‘unfaithful’, ‘adulterous’, ‘two-timing’, ‘lustful’.
- c) Social status (SS) words, consisting of: ‘cowardly’, ‘weak’, ‘submissive’, ‘subordinate’, ‘pathetic’.
- d) General negative (GN) words, consisting of: ‘selfish’, ‘dishonest’, ‘arrogant’, ‘sly’, ‘stupid’.

Therefore, there were 20 threat words included in the task. One hundred additional ‘control’ words, matched for length and frequency of occurrence in the English language (Kilgariff 1997) were also included. This enabled 60 word pairs to be presented one at a time to each participant. A word pairing could consist of either a ‘threat’ or a ‘control’ word paired together on the screen, or of two ‘control’ words paired together on the screen. Word pairings were randomly created and presented to participants in a random order. For each trial, a fixation cross appears for one second, when it disappears, two words appear on the screen (a word pair). The words remain on the screen for 500 milliseconds (based on guidelines outlined by Mogg et al. 1998). The words appear in the centre of the screen, with one word towards the top of the screen (directly above the other word), and the other word towards the bottom of the screen. There is a space of 5cm separating each word in the pair. After a ‘word pair’ disappears, a dot appears in the place of one of the words. If the dot appears in the position of a ‘threat’ word, it is referred to as a *congruent trial*. If the dot appears in the place of a ‘control’ word it is deemed an *incongruent trial*. Participants are instructed that as soon as the dot appears, to press the appropriate button on the response box to confirm the position of the dot. Fast reaction times for dots that appear in the position of threatening words, and slow reaction times for dots that appear in

the position of control words (when the control word is paired with a ‘threat’ word) indicate attentional bias towards threatening words, and thus indicate emotional reaction to threatening words. Each of the 60 word pairs was presented once each. Participants performed 15 practice trials before beginning the task proper, so as to familiarise themselves with the task. The complete list of all words (and their frequency values) used in the dot probe task are presented in Appendix 14.

For this study participants were randomly allocated (using a random sequence generator found at [www.random.org](http://www.random.org)) to complete a dot probe task in which they would be presented with either congruent or incongruent trials. Therefore, there were 4 between subject experimental groups in this study: Male congruent, Male incongruent, Female congruent, Female incongruent.

Similarly to Experiment 1, participants were instructed before commencement of the dot probe task that some of the words that appear in the task “are adjectives that could be used to describe material things in the world, and some of them could be used to describe you”. Again, this was a ruse to implant the idea that these words were referring to characteristics of the participants taking part in the task.

#### 4.3.2.6 *Ratings of verbal stimuli*

As in Experiment 1, the word categories used in this study were independently rated for offensiveness. An independent sample of 77 participants from the University of Stirling student population (20 Males and 57 females) rated the words. Males and females in this sample were matched for age. The mean age of males in this sample was 19.85 (SD=2.83; Range= 17-30), and the mean age of females in this sample was 21.00 years (SD=5.59;

Range=17- 45 years). The same questions used in Experiment 1 were used in Experiment 2. The only difference between study 1 and 2 is that participants would have to rate the offensiveness of PA and SR words rather than just FN words.

#### *4.3.2.7 Procedure*

As participants were not informed they would be receiving memory tests on the words appearing in the dot probe task, they were notified that “certain aspects of the procedure will not be explained to you now as they might bias the results of the study, but they are only minor aspects and you will receive a full debriefing at the end of the study”.

Participants then signed a consent form and then completed the dot probe task. Following this they completed a series of ‘online’ questionnaires: the Spielberger state anxiety questionnaire, the Spielberger trait anxiety questionnaire, the HADS, and the Rosenberg self esteem scale. After completing the questionnaires, participants were then informed that they would receive a surprise free recall memory test on the words that appeared in the reaction time task (excluding words that appeared in the practice phase). Participants were provided with a blank sheet of paper to write down as many words as they could remember. When participants were unable to remember any more words they were given a surprise recognition memory test, which was presented ‘online’. Following completion of the study participants were fully debriefed as to the full aims and purpose of the study.

### 4.3.3 Results - Experiment 2 Dot probe

#### 4.3.3.1 Ratings of verbal stimuli

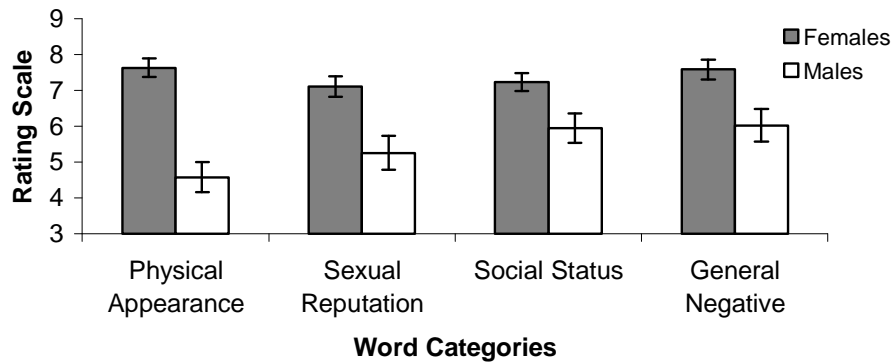
*(a) How offended would you be if the following words were used to describe you?*

Inter rater reliability for the word ratings were calculated separately for each word category (i.e. PA, SR, SS, GN), separately for female and male ratings using Cronbach's Alpha. For inter rater reliability for PA words:  $\alpha = .9$  for female raters, and  $\alpha = .8$  for male raters. For SR words:  $\alpha = .9$  for female raters, and  $\alpha = .83$  for male raters. For SS words:  $\alpha = .86$  for female raters, and  $\alpha = .85$  for male raters. For GN words:  $\alpha = .84$  for female raters, and  $\alpha = .82$  for male raters. A repeated measures ANOVA was performed on rating scale scores, with 'sex' as the between subjects factor, 'word category' as the within subjects factor and rating scale score as the dependent variable. The analysis revealed a significant between subjects effect of 'sex' [ $F(1,75)=20.171, p<.001$ ], with females being generally more offended than males (collapsing across word categories). There was a significant within subjects effect of 'word category' [ $F(3,225)=3.71, p<.001$ ], with Bonferroni pairwise comparisons revealing GN words rated as significantly more offensive than SR words [ $p=.029$ ]

The analysis also revealed a significant 'sex' \* 'word category' interaction [ $F(3,225)=4.891, p=.003$ ]. To examine this interaction, a series of one way ANOVAs, with 'sex' as the between subjects factor, was performed on each of the word category scores. This analysis revealed females reported higher levels of offensiveness for each word category [all  $p<.012$ ], however one can deduce from the graph that the interaction is

largely due to the difference between males and females in ratings of PA words, which is greater than the difference between males and females for all other word categories. See Figure 4.7.

**Figure 4.7** Self ratings of offensiveness of negative verbal stimuli. Error bars represent +1/-1 standard error of the mean.

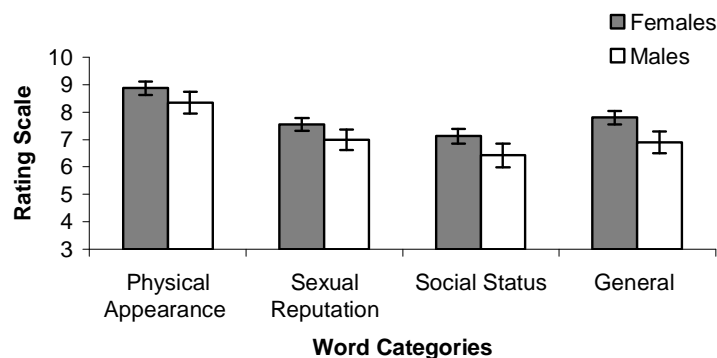


*(b) How offended would other people, who are female, be if the following words were used to describe them?*

Inter rater reliability for the word ratings were calculated separately for each word category (i.e. PA, SR, SS, GN), separately for female and male ratings using Cronbach's Alpha. For inter rater reliability for PA words:  $\alpha = .96$  for female raters, and  $\alpha = .98$  for male raters. For SR words:  $\alpha = .86$  for female raters, and  $\alpha = .91$  for male raters. For SS words:  $\alpha = .9$  for female raters, and  $\alpha = .9$  for male raters. For GN words:  $\alpha = .88$  for female raters, and  $\alpha = .89$  for male raters. A repeated measures ANOVA was performed on rating scale scores, with 'sex' as the between subjects factor, 'word category' as the within subjects factor and rating scale score as the dependent variable. The analysis revealed a marginally significant between subjects effect of sex [ $F(1,75)=2.811, p<.098$ ] (collapsing across word categories). There was a significant within subjects effect of 'word category'

[ $F(3,225)=32.429, p<.001$ ], with Bonferroni pairwise comparisons revealing PA words were rated significantly more offensive to ‘other females’ than all the other word categories [all  $p<.001$ ]. GN words were rated as more offensive to ‘other females’ than SS words [all  $p=.013$ ]. The analysis also revealed no significant ‘sex’ \* ‘word category’ interaction [ $F(3,225)=.406, p=.749$ ]. See figure 4.8.

**Figure 4.8** How offensive the verbal stimuli would be to other people, who are females. Error bars represent +1/-1 standard error of the mean.

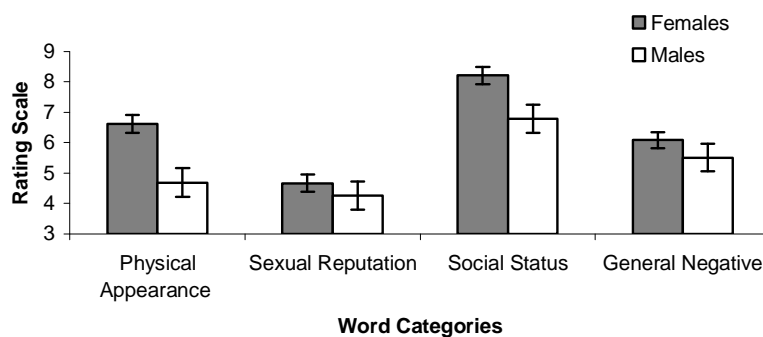


*(c) How offended would other people, who are male, be if the following words were used to describe them?*

Inter rater reliability for the word ratings were calculated separately for each word category (i.e. PA, SR, SS, GN), separately for female and male ratings using Cronbach’s Alpha. For inter rater reliability for PA words:  $\alpha = .93$  for female raters, and  $\alpha = .91$  for male raters. For SR words:  $\alpha = .88$  for female raters, and  $\alpha = .94$  for male raters. For SS words:  $\alpha = .88$  for female raters, and  $\alpha = .97$  for male raters. For GN words:  $\alpha = .9$  for female raters, and  $\alpha = .84$  for male raters. A repeated measures ANOVA was performed on rating scale scores, with ‘sex’ as the between subjects factor, ‘word category’ as the within subjects

factor and rating scale score as the dependent variable. The analysis revealed a significant between subjects effect of ‘sex’ [ $F(1,75)=5.505, p<.022$ ], with female ratings of offensiveness of the stimuli to ‘other males’ higher than males’ ratings (collapsing across words categories). There was a significant within subjects effect of ‘word category’ [ $F(3,225)=48.386, p<.001$ ], with Bonferroni pairwise comparisons revealing SS words rated significantly more offensive to ‘other males’ than all the other word categories [all  $p<.001$ ]. PA & GN words were rated as more likely to be more offensive to other males than SR words [all  $p<.001$ ]. The analysis also revealed a significant ‘sex’ \* ‘word category’ interaction [ $F(3,225)=3.72, p=.012$ ]. A series of one way ANOVAs, with sex as the between subjects variable, for each of the word category groups revealed no difference between males and females in their offensiveness ratings for SR and GN words but females showed significantly higher offensiveness ratings for PA and SS words than males [all  $p<.009$ ]. See figure 4.9.

**Figure 4.9** How offensive the verbal stimuli would be to other people, who are male. Error bars represent +1/-1 standard error of the mean.





#### 4.3.3.1. *Summary of ratings of word categories*

Thus, the analyses of the ratings of the verbal stimuli indicate that females are more offended by PA words than males. Both males and females believe that 'other' females are also more offended by these words than males. The results did not suggest that males found SS words more offensive than females when they were asked about how offensive they would find SS words personally. However, the results indicated that both males and females believe 'other' males would find these words more offensive than females. This suggests that males recognise that these types of words are generally offensive for males but that perhaps are reluctant to reveal that they find these words personally offensive.

#### 4.3.3.2 *Potentially confounding variables*

##### 4.3.3.2.1 *Four experimental groups*

Internal reliability for State anxiety, Trait anxiety and HADS depression was determined using Cronbach's Alpha. For State anxiety  $\alpha = .9$ ; for Trait anxiety  $\alpha = .91$ ; for HADS depression

$\alpha = .74$ . One way ANOVAs with performed on potentially confounding variables, with 'experimental group' as the between subjects factor (See Table 4.2). The analysis revealed no difference between the 4 groups for HADS depression and State anxiety. The groups did differ in terms of age and trait anxiety. Bonferroni pairwise comparisons revealed the significant difference in age was due to the 'Female congruent' group being marginally significantly older than the 'male congruent' group ( $p=.075$ ). Bonferroni pairwise comparisons for Trait anxiety scores revealed the significant difference was due to the 'Female incongruent' group having marginally significantly higher Trait anxiety than the

'Female congruent' group ( $p=.073$ ). As a result of these findings, Trait anxiety and age were entered as covariates in future analysis comparing across these 4 experimental groups.

#### 4.3.3.2.2 *Sex*

One way ANOVAs were performed on potentially confounding variables with 'sex' as the between subjects factor. The analysis revealed no sex differences in HADS depression and Trait and State anxiety, however, it did reveal females in the study were significantly older than males (see Table 4.2). Therefore, for all further analysis comparing between sex, age was entered as a covariate.

**Table 4.2** Summary of potentially confounding variables

	Females (N= 52)				Males (N= 40)				F	P
	Congruent (23)		Incongruent (29)		Congruent (20)		Incongruent (20)			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Age	24.42	9.01	23.34	6.27	19.85	1.5	20.27	3.18	3.28	.024*
Trait A	40.32	9.52	47.62	13.12	42.15	9.03	40.45	8.49	2.91	.04*
State A	36.04	11.20	40.41	11.29	36.3	5.23	37.59	9.96	1.07	.37
HADS D	7.8	1.60	7.79	1.80	7.9	2.10	8.91	2.37	1.74	.164
Total Age	Mean = 23.85 (SD=7.63)				Mean= 20.07 (SD=2.5)				9.51	.0026* *
Total Trait A	Mean= 44.24074 (SD=12.066)				Mean=41.26 (SD=8.687135)				1.82	.180
Total State A	Mean= 38.389 (SD= 11.37)				Mean= 36.97619 (SD= 7.99)				0.46	.495
Total HADS D	Mean= 7.79629 (SD= 1.697)				Mean= 8.428 (SD= 2.275)				2.43	.122

**Key:** SD = Standard deviation. Trait A = Trait anxiety, State A = State anxiety. HADS D = HADS depression

#### 4.3.3.3 Dot Probe reaction time analysis

Based on previous research employing the dot probe task (Egloff & Hock 2003) trials with reaction time < 150ms or > 1200 ms were excluded from analysis (1.8% of trials).

##### 4.3.3.3.1 Baseline Reaction time

In order to assess baseline RT, RT for responses to probes appearing after a word pair consisting of 2 neutral words were compared between groups. A univariate ANOVA, with 'sex' and 'probe congruency' as the between subject factors and RT for 'Control' stimuli

(the baseline measure of RT) as the dependent variable revealed no differences in baseline RT between males and females [ $F(1,88)=.028, p=.868$ ], or between Congruent and Incongruent groups [ $F(1,88)=2.712, p=.103$ ]. Neither was there as ‘sex’ \* ‘probe congruency’ interaction in baseline reaction time scores [ $F(1,88)=.043, p=.837$ ].

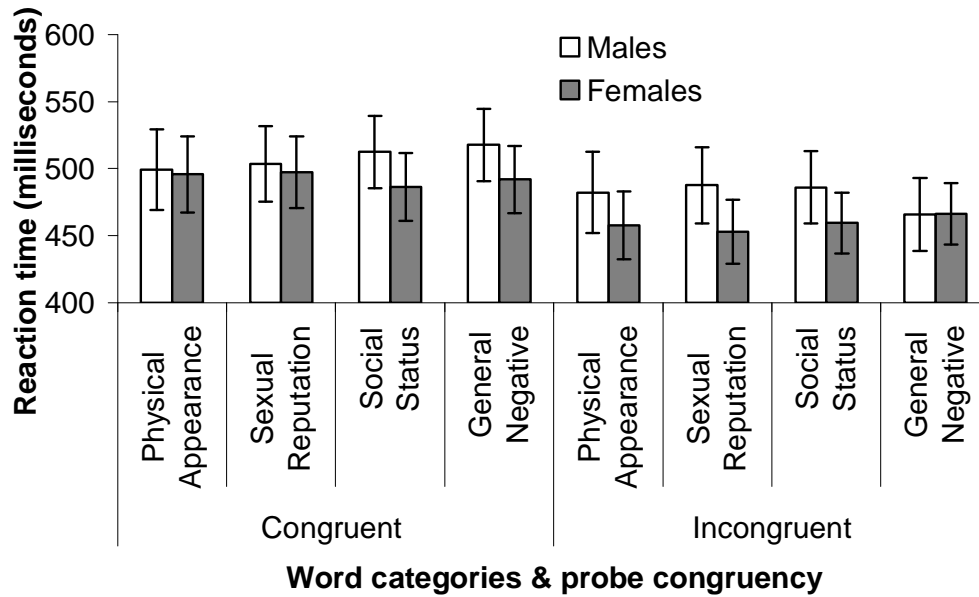
**Table 4.3** Baseline RT

Sex	Probe Congruency	Mean	SD	N
Females	Incongruent	453.02	91.62	29
	Congruent	495.33	94.55	23
	Total	471.73	94.42	52
Males	Incongruent	461.53	106.29	20
	Congruent	494.41	142.21	20
	Total	477.97	125.06	40
Total	Incongruent	456.49	96.89	49
	Congruent	494.90	117.61	43
	Total	474.44	108.2	92

#### 4.3.3.3.2 *Reaction time for threatening stimuli*

A mixed factor repeated measures ANOVA, with sex (males and females) and ‘probe congruency’ (congruent and incongruent) as the between subjects factors, word category (Physical Appearance, Sexual Reputation, Social Status, General Negative) as the within subjects factors, and RT as the dependent variable was performed. The analysis did not reveal a significant ‘sex’ \* ‘probe congruency’ \* ‘word category’ interaction on RT scores [ $F(3,258)=1.984, p=.117$ ]. There was also no main effect of ‘sex’ [ $F(1,86)=.461, p=.499$ ] or of ‘probe congruency’ on RT scores [ $F(1,86)=1.51, p=.223$ ]. See Figure 4.10.

**Figure 4.10** Dot Probe reaction time scores for threatening verbal stimuli. Error bars represent +1/-1 standard error of the mean.



#### 4.3.3.4 Free recall memory

##### 4.3.3.4.1 Baseline free recall memory: Males versus Females

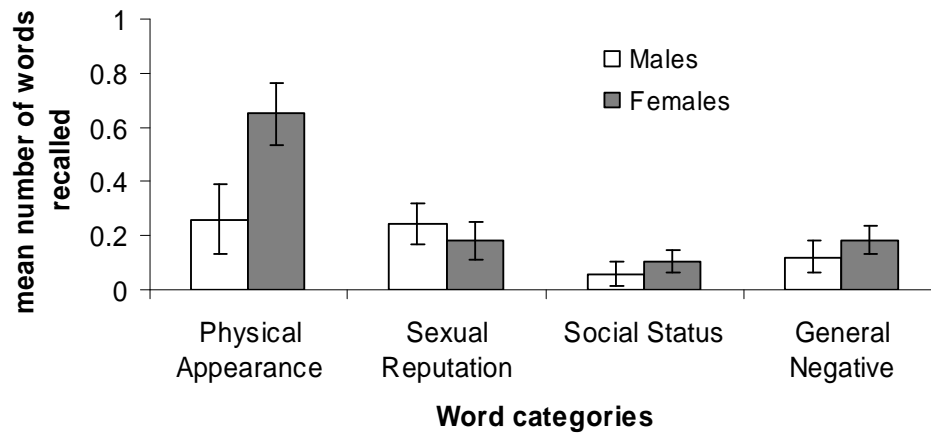
In order to assess any potential sex differences in participants' baseline free recall memory ability, recall for the emotionally neutral 'control' words was analysed. A one way ANOVA with 'sex' as the between subjects factor and free recall memory for 'control' words (baseline memory variable) as the dependent variable revealed no difference between males (N= 42, mean= .07; SD= .26) and females (N=55; mean= .07; SD= .26) [F(1,95)=.001, p=.98].

#### 4.3.3.4.2 *Free recall memory for threatening verbal stimuli*

A repeated measures ANOVA, with sex as the between subjects factor, word category as the within subjects factor, and free recall memory score as the dependent variable was performed. The analysis revealed a marginally significant between subjects effect of 'sex' on free recall memory scores [ $F(1,92)=3.816, p=.054$ ]. There was also a main within subjects effect of 'word category' [ $F(3,276)=3.421, p=.018$ ]. Bonferroni pairwise comparisons revealed greater memory for PA words than SR [ $p=.097$ ], SS [ $p<.001$ ] and GN [ $p=.012$ ] word categories .

There was also a significant 'word category' \* 'sex' interaction [ $F(3,276)=2.776, p=.042$ ] on free recall memory scores. A series of one way ANOVAs, with sex the between subjects factor, on each of the 'word categories' scores, revealed the interaction was due to marginally significantly greater memory for PA words for females than males [ $F(1,95)=3.07, p=.083$ ]. There were no significant differences between the sexes on the remaining word categories. See Figure 4.11.

**Figure 4.11** Free recall memory for threatening verbal stimuli. Error bars represent  $\pm 1$  standard error of the mean.



#### 4.3.3.5 Recognition memory

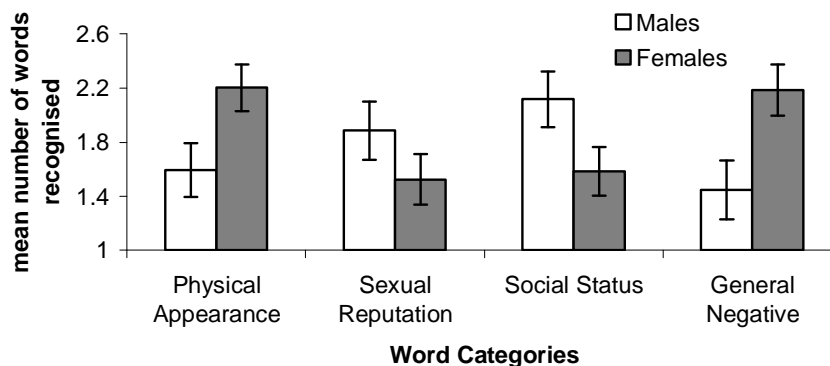
##### 4.3.3.5.1 Baseline recognition memory: Males versus Females.

In order to assess any potential sex differences in participants' baseline recognition memory ability, recognition memory for the emotionally neutral 'control' words was analysed. A one way ANOVA with 'sex' as the between subjects factor and recognition memory for 'control' words (baseline memory variable) as the dependent variable revealed no difference between males (N= 42; mean= 5.36; SD= 3.84) and females (N=44; mean= 4.7; SD= 3.4) [ $F(1,84)=.76, p= .39$ ].

#### 4.3.3.5.2 Recognition memory for threatening verbal stimuli

A repeated measures ANOVA, with sex as the between subjects factor, word category as the within subjects factor and recognition memory score as the dependent variable was performed. The analysis revealed no between subjects effect of 'sex' on recognition memory [ $F(1,94) = .459, p = .500$ ]. There was also no main effect of 'word category' [ $F(3,282) = 1.154, p = .328$ ] on recognition memory. There was a significant 'word category' \* 'sex' interaction [ $F(3,282) = 7.319, p < .001$ ]. A series of univariate ANOVAs, with sex as the between subjects factor, was performed on each of the 'word category' groups. This analysis revealed the interaction was due to significantly greater memory for PA and GN words for females than males [ $F(1,94) = 5.042, p = .027$ ] and [ $F(1,94) = 6.184, p = .015$ ] respectively but with males showing marginally significantly greater memory for SS words than females [ $F(1,94) = 3.625, p = .06$ ]. See Figure 4.12.

**Figure 4.12** Recognition memory for threatening verbal stimuli. Error bars represent +1/-1 standard error of the mean.





### 4.3.3.6 Self esteem

#### 4.3.3.6.1 Self esteem and reaction times

Internal reliability for Rosenberg self esteem was determined using Cronbach's Alpha:  $\alpha = .81$ . Rosenberg self esteem was also correlated with reaction time scores for each experimental group: 'female congruent', 'female incongruent', 'male congruent', 'male incongruent'. A Shapiro Wilks test revealed RT scores were normally distributed for each of the experimental groups, therefore Pearson's product moment correlation was used to examine the relationship between RSE and RT scores. As can be seen from Table 4.4 no significant results were found.

**Table 4.4** Rosenberg self esteem and reaction time scores.

Male N=42 Female N=51			RT_PA	RT_SR	RT_SS	RT_GN
Self Esteem ↓	Probe Congruency					
Females Mean=21 (SD=6.26)	Congruent	R	-.196	-.078	-.223	-.198
	N=20					
	Mean= 18.7 (SD=5.681)	P	.407	.745	.345	.403
	Incongruent	R	.021	.071	-.039	-.065
Males Mean=18.76 (SD=5.2)	N=29					
	Mean= 22.69 (SD=6.25)	P	.915	.714	.841	.738
	Congruent	R	-.290	-.152	-.307	-.214
	N=20					
Males Mean=18.76 (SD=5.2)	Mean= 18.05 (SD=3.86)	P	.215	.522	.189	.364
	Incongruent	R	.097	.032	.151	.049
	N=20					
	Mean= 19.41 (SD=6.22)	P	.557	.845	.361	.769

**Key:** RT\_PA: Reaction time for 'physical appearance' words. RT\_SR: Reaction time for 'sexual reputation' words.  
RT\_GN: Reaction time for 'general negative' words

4.3.3.6.2 *Self esteem and memory*

A Shapiro Wilk test on the variables listed below in Table 4.5 revealed only RSE scores were normally distributed. Therefore a Spearman’s rho correlation was used to investigate the relationship between RSE and free recall and recognition memory for the 4 word categories. The analysis revealed that in females, RSE was significantly positively correlated with recognition memory for PA words (high RSE means low self esteem). Self esteem did not correlate with memory for any other word category for either males or females (see Table 4.5 below for analysis).

**Table 4.5** Rosenberg Self esteem & memory for verbal stimuli

Male N=42 Female N=51		FR_PA	FR_SR	FR_SS	FR_GN	RM_PA	RM_SR	RM_SS	RM_GN
Self Esteem ↓									
Females Mean=21 (SD=6.26)	R	-.079	.166	.157	.193	.291	.204	.187	.246
	P	.584	.246	.270	.175	.039*	.150	.188	.082
Males Mean=18.76 (SD=5.2)	R	-.281	-.229	.203	-.100	-.280	-.154	-.075	.018
	P	.071	.144	.198	.527	.073	.331	.635	.909

**Key:** FR\_PA: Free recall of ‘physical appearance’ words. FR\_SR: Free recall of ‘sexual reputation’ words. FR\_GN: Free recall of ‘general negative’ words. RM\_PA: recognition memory of ‘physical appearance’ words. RM\_SR: recognition memory of ‘sexual reputation’ words. RM\_SS: recognition memory of ‘social status’ words. RM\_GN: recognition memory of ‘general negative, words.

#### **4.3.4 Discussion**

##### *4.3.4.1 Offensiveness ratings*

The results of the offensiveness ratings of verbal stimuli showed a similar pattern to the results found in Experiment 1. Again males rated SS words as relatively more offensive for ‘other males’ than for themselves; with SR words deemed least likely to cause offence to ‘other males’. Similarly, females rated PA words as relatively more offensive for ‘other females’ than for themselves. The ratings of the verbal stimuli confirmed the validity of the stimuli for use in the dot probe task.

##### *4.3.4.2 Reaction times*

As with Experiment 1, the dot probe task failed to reveal any differential effects of the verbal stimuli on emotional arousal for either males or females. Research employing the dot probe task has had more success in clinical populations (Mogg et al. 1998), nevertheless it has also been used successfully to detection attentional biases in non-clinical samples (e.g. Koster et al. 2004), and thus the reason it was chosen for this experiment. A short coming of the dot probe task in this study is that each ‘offensive’ stimulus was only presented once. Research using the dot probe task usually repeats presentation of a set of stimuli, rather than displaying each ‘threat’ word once (e.g. Gotlib et al. 2004). The reason ‘threat’ words were only displayed once per participant in this study was to avoid a ‘ceiling effect’ in memory performance for threat words in the subsequent memory tests.

#### 4.3.4.3 *Memory*

In line with the stated predictions, free recall memory scores showed females had marginally significantly greater memory for PA words than males. Males however did not show enhanced memory for SS words. However, male scores on the recognition memory test were considerably different than their free recall scores, as a significant ‘sex’ by ‘word category’ interaction on recognition memory scores revealed. Males showed marginally significantly greater memory for SS words than females, with females showing significantly greater memory for PA and GN words than males. As suggested in the discussion section in experiment 1, the more anonymous nature of the recognition memory test may have allowed males to feel more comfortable in performing the memory test, as their pattern of performance in the free recall test seems to mirror their performance in the recognition memory test (see Figures 4.11 and 4.12). Females however, did not show enhanced memory for SR words as predicted, but did show enhanced memory for GN words compared to males, which was not predicted.

#### 4.3.4.4 *Self esteem*

Self esteem was shown to negatively correlate with recognition memory for PA words in females, as predicted. This finding supports the hypothesis that self-esteem is more closely tied to physical appearance in females than in males. However, self esteem did not correlate with any other reaction time or memory variables. It could be argued that this significant correlation was a chance finding as the number of correlations being performed increased the probability of a Type I error occurring. Therefore further research will be required before one can declare the above finding robust and replicable.

#### 4.4 General Discussion of Experiments 1 & 2

The emotional Stroop and dot probe tasks failed to detect a differential emotional reaction between males and females to the different 'threat' stimuli. Although the literature shows both these experimental paradigms are more successful at detecting emotional reactions when testing clinical samples, however, a possible short coming of the use of the emotional Stroop and dot probe tests in this study is that each 'threat' word is only presented once. Research employing these experimental paradigms typically repeats a set of stimuli, rather than displaying each 'threat' word once. The reason 'threat' words were only displayed once per participant in this study was to avoid a 'ceiling effect' in memory performance for threat words in the subsequent memory tests (i.e. multiple exposure to the threat words may have meant no differences in memory performance would emerge).

The fact that females showed marginally significantly greater recognition memory than males for FN words in Experiment 1, and significantly greater free recall and recognition memory than males for PA words in Experiment 2, strongly suggests that females are more concerned with physical appearance than males. The significant negative correlation between recognition memory for PA words and self esteem may also suggest the importance of 'self perception of physical attractiveness' for female self esteem and well being. The performance of males on the more 'anonymous' recognition memory test in Experiment 2, coupled with how two independent samples of males rated SS threat words as more offensive to 'other males' relative to themselves, suggests that male free recall memory scores in both experiments may not be an accurate indicator of how emotionally arousing male participants actually found the SS words. Male depression scores were significantly greater than females' in Experiment 1, this may also of had a bearing on the between sex differences in memory scores and reaction time performance. This

discrepancy in depression scores seems spurious (there was no sex differences in Experiment 2) and future research with males and females matched for depression will determine what effects, if any, the elevated depression scores in Experiment 1 had on reaction time and memory scores.

#### *4.4.1 Did memory and emotion interact in an adaptive fashion?*

Considering that physical appearance appears to be more important for females than males; in terms of reproductive success and self esteem, the results of these experiments suggest memory and emotion interacted in an adaptive fashion. Feedback on physical appearance is important for females to enable them to modify their appearance and in making estimates of their own 'mate value'. Therefore, remembering offensive descriptions of one's physical appearance is an adaptive response as it allows action to be taken to modify appearance if necessary. Similarly, if slights against male 'status' or 'rank' go unnoticed it does not afford a male the opportunity to take action to modify the situation if necessary. Results of the recognition memory test in Experiment 2 suggest memory and emotion interacted in an adaptive fashion for both males and females.

#### *4.4.2 Implications for future research*

The finding that males rate social status 'threat' words as likely to be relatively more offensive to other males than to themselves may have implications for future research in the field of individual differences and personality psychology. Participants in this study may either be consciously or subconsciously denying that certain personality characteristics are important to them, while, nevertheless assuming they are important for others.

Additionally, the difference in male memory performance between the free recall tests in Experiments 1 and 2 and the recognition memory test in study 2 suggest the importance of perceived anonymity in research of this nature. Online questionnaires, for example, have an ‘anonymous’ feel to them, with the responses ‘disappearing’ from view once the ‘submit’ button is pressed. Participants may have less fear that the experimenter will accidentally see their responses and ‘pass judgement’ on them.

#### *4.4.3 Conclusion*

Females showed marginally significantly greater recognition memory than males for FN words in Experiment 1, and significantly greater free recall and recognition memory than males for PA words in Experiment 2. These findings strongly suggest that females are more concerned with physical appearance than males. The recognition memory scores of the second experiment showed a significant interaction in memory performance in the hypothesized direction; females showed greater memory for ‘physical appearance’ words with males superior memory for ‘social status’ words. The second experiment also showed a significant negative correlation between recognition memory for ‘physical appearance’ words and self esteem in females. Thus females with low self esteem have better memory for threatening stimuli relating to physical appearance. This later result highlights the importance of ‘self perception of physical attractiveness’ for female self esteem and well being. The results of both experiments provide evidence that memory and emotion do interact in an adaptive fashion for males and particularly females.

## **Chapter 5 Investigating sex differences in memory for, and arousal to, cues to emotional and sexual infidelity**

### **Abstract**

#### *Aims*

To investigate whether:

- a) Males will be more emotionally aroused by and have greater memory for cues to a partner's *sexual* infidelity.
- b) Females will be more emotionally aroused by, and have greater memory for, cues to a partner's *emotional* infidelity.
- c) Females in a committed relationship will show greater emotional arousal to, and enhanced memory for, cues to sexual infidelity than females not in a relationship.

#### *Methods*

Participants listened to an emotionally arousing narrative containing cues to emotional infidelity and cues to sexual infidelity, and also a 'neutral' narrative matched for word length and amount of information. Galvanic Skin Response (GSR) was recorded for the duration of both narratives to give an index of emotional arousal to the infidelity cues. A thirty minute delay period followed presentation of the stories, after which participants were given a free recall memory test on both stories.

#### *Results*

Females did not show enhanced GSR activity or memory for cues to emotional infidelity. Likewise, males did not display enhanced GSR activity or memory for cues to sexual infidelity. Males and females currently in a committed relationship elicited greater GSR activity in response to cues to sexual infidelity, but they did not show enhanced memory for these cues. GSR activity in response to cues to sexual and emotional infidelity did not correlate with memory for those cues.



## *Conclusion*

The results of this experiment suggest that regarding relationship jealousy, memory and emotion does not seem to function in a hard-wired, sex specific manner, instead contextual factors may be important, such as relationship status and individual differences in what type of infidelity people find more emotionally arousing and thus more memorable.

## **5.1 Introduction**

This chapter aims to investigate whether memory and emotion interact differently for males and females in response to cues to infidelity, and in a manner adaptive to their reproductive success. As described in Chapter 1, a vast literature exists supporting the ‘innate module theory’ of sexual jealousy: that men are predisposed to be upset by a mate’s sexual infidelity, whereas women are predisposed to be upset by a mate’s emotional infidelity (e.g. Buss 2003). However, researchers such as Harris (e.g. 2003a) refute this hypothesis and instead argue that there is no clear evidence that males and females are innately wired to be more concerned with differing forms of infidelity. Harris contends that contextual factors such as relationship experience may in fact have a more important role to play. In a previous study Harris (2003b) found no difference in the degree to which the sexes focused on the sexual versus emotional aspects of a partner’s *actual* infidelity. However, greater experience with committed relationships was positively correlated with greater sexual jealousy over a mate’s actual infidelity for males and females. Harris postulates that sex may become more important to an individual’s self-concept within a relationship as the relationship develops over time.

### *5.1.1 The present study*

The present study is interested in how memory and emotion interact in responses to cues to sexual and emotional infidelity. Participants will be asked to listen to a 'neutral' and 'arousing' narrative involving two people in a committed relationship and imagine it is themselves and their partner. The Arousing Narrative (AN) will contain cues to both emotional and sexual infidelity, while the Neutral Narrative (NN) will contain events of an emotionally neutral nature. GSR will be recorded during both narratives and participants will be given a free recall memory test on both narratives after a thirty minute delay period. GSR is a reliable indicator of sympathetic activation of the autonomic nervous system (Levenson 1988) and has been shown to correlate with emotional arousal with fear and disgust producing larger responses than happiness (Levenson 1992). For the purpose of this study, GSR activity will be used as a psychophysiological index of emotional arousal. The innate modular view of sexual jealousy predicts that males will display greater GSR activity to, and enhanced memory for, cues to sexual infidelity, whereas females will display greater GSR activity to, and enhanced memory for, cues to emotional infidelity.

The study also aims to extend findings relating to the Socio-Cognitive stand point of sexual jealousy. Attitudes towards sex (indexed by the attitude component of the Sociosexual Orientation Inventory, SOI) and relationship status (those in a relationship versus those not in a relationship), and how they affect GSR activity and free call memory for cues to emotional and sexual infidelity will be examined. Only one previous known study to date has examined the relationship between sociosexuality and sex differences in jealousy, with no clear relationship emerging (Harris 2003b). Individuals that score highly on the SOI (i.e. have an unrestricted SOI) require less love, investment, commitment and emotional bonding before engaging in sex in a relationship (Simpson & Gangestad 1991b). They also

tend to date partners who are more socially visible and attractive and rate these traits as more important than those scoring low on SOI (restricted SOI individuals). Those with restricted SOI scores (low SOI scores) tend to attach more value to personal and parenting qualities in a potential mate and date individuals who are more responsible, faithful/loyal, and affectionate (Simpson & Gangestad 1992).

Considering this evidence it is hypothesized that individuals of restricted SOI will be more distressed by the thought of a partner's emotional and sexual infidelity as they attach more importance to faithfulness and deep emotional bonds within a relationship than those of unrestricted SOI. Those of restricted SOI are predicted to show greater GSR activity and enhanced memory for cues to both emotional and sexual infidelity. Relationship status will also be examined in this study. It is hypothesized that infidelity cues will be more meaningful and feel more vivid and tangible for those currently engaged in a relationship as opposed to those who are not. For this reason it is predicted that those in a relationship will have greater GSR activity and enhanced memory for cues to both emotional and sexual infidelity. This study is interested in whether physiological arousal and memory interact in an adaptive fashion; are cues that elicit greater physiological arousal remembered better? Such an effect is predicted by an evolutionary standpoint which argues that emotions have been designed by natural selection to help us navigate our way through our environment in a manner adaptive for our survival and reproduction (Damasio 1999). Enhanced memory for cues to infidelity would be adaptive as it means individuals would be able more successful at taking action and detecting such cues in the future and research suggests that physiological arousal during emotional events enhances memory for those events (McGaugh 2000).

### 5.1.2 *Hypotheses and predictions*

1. Males will show greater GSR activity to, and enhanced memory for, cues to sexual infidelity, whereas females will display greater GSR activity to, and enhanced memory for, cues to emotional infidelity.
2. Those of restricted SOI are predicted to show greater GSR activity and enhanced memory for cues to both emotional and sexual infidelity.
3. Those in a relationship will have greater GSR activity and enhanced memory for cues to both emotional and sexual infidelity.
4. Cues that elicited greater GSR activity will be remembered better.

## 5.2 **Pilot study**

In order to determine what cues are to be designated as cues to emotional infidelity and which cues are to be designated as cues to sexual infidelity, a preliminary study was conducted in which participants rated ten cues as to whether they thought they were cues indicative of emotional or sexual infidelity. The ten cues relating to infidelity used in this study were created and identified by Shackelford & Buss (1997) and employed by Schutzwohl & Koch (2004). Schutzwohl & Koch (2004) identified five cues as being more diagnostic of emotional infidelity and five cues as being more diagnostic of sexual infidelity. Rather than relying on this categorization, we asked a separate sample of University of Stirling students to rate whether they thought each of the cues were more indicative of cues to emotional or sexual infidelity. This modified diagnosis was then used for future analysis involving cues to emotional and sexual infidelity in this study.

## 5.2.1 Methods

### 5.2.1.1 Participants

Forty seven females (mean age= 20.53, SD= 2.6) and twenty seven males (mean age= 19.79, SD= 2.2) from the University of Stirling student population were asked to rate ten cues relating to a partner's imagined infidelity, as being either more diagnostic of emotional infidelity or sexual infidelity. Course credit reward was used as incentive for taking part. Ethical approval to carry out this study was granted by the University of Stirling Department of Psychology Ethics committee. An application with a detailed description of the study was submitted to this committee detailing the full aims and methodology of the proposed research. This committee made their decision to approve this study after careful analysis of this application.

### 5.2.1.2 Infidelity cues

The ten cues relating to infidelity used in this study were identified by Shackelford & Buss (1997) and employed by Schutzwohl & Koch (2004). See Tables 5.3 and 5.4 for cues.

### 5.2.1.3 Procedure

Participants were presented with the cues via an on-line questionnaire. They were instructed to decide whether the following cues to infidelity related more to emotional or sexual infidelity. Emotional infidelity was defined as forming a close emotional attachment involving investment of attention and time in a member of the opposite sex while still involved in a relationship. Sexual infidelity was defined as engaging in sexual

activity, and being sexually attracted to, another member of the opposite sex while still in a relationship, without an emotional attachment to this person.

### **5.2.2 Results and Discussion**

Chi square analysis was employed to determine what cues would be categorized as cues to emotional infidelity, and what cues would be categorized as cues to sexual infidelity. See Table 5.1 & 5.2 for results of analysis

**Table 5.1 Ratings of cues into sexual and emotional infidelity categories.**

	Infidelity cues	Number of individuals who rated cues as emotional infidelity cues and as sexual infidelity cues							
		Males				Females			
		EIC	SIC	$\chi^2$	P	EIC	SIC	$\chi^2$	p
1	Recently your partner has not wanted to go out very often with you	20	7	14	.001	26	3	6.26	.012
2	It strikes you suddenly that your partner's clothes style has suddenly changed a lot recently	7	7	.18	.911	13	19	.186	.911
3	Recently it seems like your partner is only looking for reasons to argue with you	19	2	19.58	.001	32	8	17.56	.001
4	Recently it seems that your partner was bored when you slept with each other.	1	25	22.65	.001	8	33	42.67	.001
5	Recently your partner has difficulty getting sexually aroused	3	19	8	.018	11	27	16.89	.001
6	You whisper into your partner's ear "I love you" however, she doesn't respond	19	3	37.02	.001	37	3	16.89	.001
7	You tell your partner that you met your friend Thomas today. When she hears his name she becomes nervous	5	14	37.02	.001	8	25	16.89	.001
8	Rather than talking about Thomas, your partner changes the subject and starts telling you details of what she did today	4	18	6.836	.03	10	24	1356	.001
9	You and your partner are out together for a meal. Although she has been acting coldly towards you all night, all of a sudden, she begins to act overly affectionate towards you	6	7	.61	.739	19	19	4.2	.121
10	You and your partner come home after having a couple of drinks, you kiss your partner and say that you would like to sleep with her tonight, however she says that he doesn't feel like it tonight	1	12	8	.018	11	24	16.89	.001

Key: EIC= emotional infidelity cues, SIC= sexual infidelity cues.

The following cues were designated cues to Emotional and Sexual infidelity, 2 cues were excluded from this categorization.

**Table 5.2 Cues to Emotional and Sexual infidelity**

<b>Cues to emotional infidelity</b>	<b>Cues to Sexual infidelity</b>	<b>Ambiguous cues</b>
1) Recently your partner has not wanted to go out very often with you	4) Recently it seems that your partner was bored when you slept with each other	2) It strikes you suddenly that your partner's clothes style has suddenly changed a lot recently
3) Recently it seems like your partner is only looking for reasons to argue with you	5) Recently your partner has difficulty getting sexually aroused	9) You and your partner are out together for a meal. Although she has been acting coldly towards you all night, all of a sudden, he/she begins to act overly affectionate towards you
6) You whisper into your partner's ear "I love you" however, she/he doesn't respond	7) You tell your partner that you met your friend Thomas today. When she hears his name she becomes nervous	
	8) Rather than talking about Thomas, your partner changes the subject and starts telling you details of what she did today	
	10) You and your partner come home after having a couple of drinks, you kiss your partner and say that you would like to sleep with her tonight, however she says that she doesn't feel like it tonight	

All ten cues that were rated in this pilot study will be included in the Arousing Narrative in study 2. However, when analyzing GSR activity and memory for cues to sexual and emotional infidelity, the 2 ambiguous cues will not be included in analysis.



## 5.3 Main study

### 5.3.1 Methods

#### 5.4.1. Participants

The sample size for this study was chosen using power analysis. An effect size of .4 was entered into a Power analysis software program (GPower™), in which Alpha was set at .05, power at .8, and number of groups at 2. This program computed a total sample size of 62 participants. Thirty three females (mean age=21.46 years) and twenty nine males (mean age=23.18 years) from the University of Stirling student population were recruited for this study using monetary and/or course credits reward as incentive for participation.

#### 5.3.1.2 Infidelity cues and narratives

The cues to infidelity are embedded in a story involving two people in relationship. This format was originally employed by Schützwohl (2004b). This narrative containing the cues to emotional and sexual infidelity is labeled the Arousing Narrative (AN). In order to obtain baseline GSR and memory, a matched narrative that is neutral in terms of emotional arousal was created. This narrative contains two people in a relationship, and is matched for word length and number of distinct details (see Table 5.3). Before presentation of either the Neutral Narrative (NN) or the AN participants were instructed that “this narrative concerns two people in a committed heterosexual relationship. The narrative will refer to you and your partner...If you have a partner please imagine it is you and him/her, if you do not have a partner please imagine it is someone you have been with in the past or

someone you would like to be with in the future”. Participants listened to the narratives via headphones.

Table 5.3 Emotionally Arousing Narrative

Your partner and you want to go out tonight. You are looking forward to going out because 1 recently he has not wanted to go out with you. You decide to drive into town to eat in your favourite restaurant. As you are leaving the house it strikes you 2 suddenly that his clothes style has suddenly changed a lot recently. You decide to drive. The whole journey into town 3 your partner overreacts to driving mistakes he thinks you are making even though you know you have not made any. It seems like he is only looking for reasons to argue with you. When you must wait shortly at a red traffic light you think of last night. It seemed 4 like he was bored when you slept with each other. You also remember 5 he had difficulty getting sexually aroused. You arrive at the restaurant and get out. While walking to the entrance 6 you whisper into his ear 'I Love you', however, he doesn't respond. You sit down to an empty table. While you wait for the waiter you chat a little. You tell him that you met your friend Annette today. 7 When he hears her name he becomes nervous. You start telling him about the news you heard from Annette. Suddenly your partner starts telling you details of about what he did today, 8 he avoids speaking about Annette. The waiter arrives and you order food. While you wait 9 your partner begins to act overly affectionate towards you. The food arrives and it tastes excellent. Following the meal you have a drink and then go home. When you arrive home you kiss him in the hall and say you would like to sleep with him tonight, he 10 says he doesn't feel like it tonight. You watch TV together for an hour and then go to bed, the evening is over.

**Key:** Pink = cues to sexual infidelity, yellow = cues to emotional infidelity, grey = ambiguous cues

Table 5.4 Neutral Narrative

You and your partner want to drive to the park to go for a walk their together. You are looking forward to the walk as you want to spend 1 some quality time with your partner. Your partner puts on a 2 brown jacket as it is a little windy. You decide you'll drive. On your way there your partner 3 gives you directions as you've never been their before. When you must wait at a stop light you think of last night, when you and your partner 4 saw a movie together, you 5 both thought it was very good. You arrive at the park and get out. While arriving at the entrance you whisper into her ear, 6 I hope we get to see the ducks in the lake. She replies "I do too". You walk together on a lane way under some trees. You and your partner start chatting, you tell her about how you met your friend Michael today. 7 The two of you chat about Michael. 8 You tell her about what each of you did today. You finally arrive at the lake our partner points at eh duck s in the lake. 9 You both watch the ducks swimming in the lake for a while and are glad you got to see them. Following this you each buy something to drink in the park shop and then go home. 10 When you arrive home you ask our partner if she would like to watch a move with you tonight. Your partner says she would like to. You watch a movie together and then go to bed.

The neutral narrative is matched for 'number of details' with the arousing narrative. Details are numbered 1 to 10.

### 5.3.1.3 Socio-sexuality inventory (SOI)

The standard version of the SOI consists of five self report indices answered on a 9 point scale , where 1= strongly disagree and 9=strongly agree: (a) number of different sexual partners in the preceding twelve months, (b) number of different sex partners foreseen in next five years, (c) number of times having sex with someone only one occasion, (d) frequency of sexual fantasies involving individuals other than your own partner, and (e) three aggregated items tapping attitudes towards engaging in casual, uncommitted sex (e.g. "I can imagine my self being comfortable and enjoying casual sex with different partners" (Simpson & Gangestad, 1991b). Higher scores indicate an unrestricted SOI. Due to the

ethical considerations of asking students to impart such sensitive and confidential information of a very personal nature it was decided to only present them with the fifth index of SOI; the 3 items tapping attitudes towards engaging in casual uncommitted sex (see Appendix 16). A median split of SOI scores was used to determine the Low and High SOI groups. Four participants' scores fell on the median value and they were excluded from SOI categorization.

#### *5.3.1.4 Galvanic skin response recording*

GSR recording is a reliable autonomic indicator of sympathetic nervous system arousal (Hughdahl 2001). An AD Instruments ML 116 Amp and Powerlab™ unit connected to a computer running Chart™ software was used to measure and record GSR. The GSR Amp is a fully isolated, 75Hz, constant Voltage GSR amplifier with low voltage AC excitation and automatic zeroing. GSR is a measure of the skin's conductance between two electrodes. It is measured by applying a small AC signal through 2 electrodes, placed on the fingers. A response is seen as a change in conductance of skin over time. An increase in conductivity arises through increased skin moisture and/or pre-secretory activity of the sweat glands. GSR can vary due to activity of an individual's autonomic nervous system or more specifically, their sympathetic nervous system (AD Instruments 1997). Electrodes were attached to the palmar surfaces of the first and second fingers of the non-dominant hand. The sampling rate was set at 10/s. GSR was recorded one minute prior to the first narrative presentation to habituate participants to wearing the GSR cuffs. GSR was then recorded for the duration of both the NN and AN (presented in random order across participants using a random number generator found at random.org). The experimenter and participant listened to the narratives simultaneously, via two separate sound proof headphones on either side of a partition. This allowed the experimenter to event mark each

of the cues to emotional and sexual infidelity as they were appeared in the AN, while ensuring privacy for the participant.

Based on the guidelines for scoring GSR data outlined by Martin & Venables (1980), the GSR recordings from this study were scored in terms of a response frequency score (or responsivity score). This score was derived based on the number of GSR responses per narrative (an increase of .02 microsiemens, within a rise time of 2.5 seconds was the criteria used to determine whether there was a GSR response occurred). This method allowed one to see whether a specific cue had in fact elicited a GSR response. Sixteen participants' GSR data was excluded from analysis (7 males, 9 females) due to complete absence of GSR activity in response to the narratives.

#### *5.2.1.5 Memory scores*

The AN and NN were matched for word length and for eventful interactions involving “you and your partner”. There are ten details that can be remembered in the AN (i.e. the 10 cues to infidelity) and these are matched by ten discrete events involving the couple in the NN. Therefore the maximum memory score obtainable for each narrative is 10, and the lowest is 0. Therefore the 2 ambiguous cues are included in the analysis when comparing the AN versus the NN. However, when looking specifically at memory for cues to emotional versus sexual infidelity, memory for the ambiguous cues are not included in the analysis.

#### 5.2.1.6 Procedure

Participants were tested in a room partitioned in two halves with a screen. They were informed that the premise of the study was to look at “feelings and attitudes towards long-term relationships”. They were informed they would listen to two narratives involving two people in long-term committed relationships and that their GSR would be recorded as they listened to these narratives. Participants were informed that their GSR activity would give an indication of how they “feel” about both narratives. Participants were not informed about the true aim of the study as this might confound GSR activity and memory for infidelity cues. Participants were informed that certain minor aspects of the study had not been explained to them as they might bias the results but that they were not of an ethically unsound nature. After signing the consent form participants were informed that it was now time to listen to the narratives involving two people in a committed heterosexual relationship. Presentation of narratives was randomly ordered (using a random number generator found at [www.random.org](http://www.random.org)). Participants sat on one side of the screen and the experimenter on the other. Participants then completed the modified version of the SOI, a short demographics questionnaire and two ‘filler’ questionnaires: the Bem Sex Role Inventory (BSRI) the Big Five personality questionnaire, and the Spielberger State and Trait anxiety questionnaires. A free recall memory test of both narratives was then administered, in which participants were instructed to recall as many details as possible of both narratives including the story line. Responses were recorded via microphone on to a computer using Cooledit™ software. The experimenter left the room during in order for participants to provide greater privacy for participants during the free recall test. Participants were fully debriefed as to the nature of the study immediately following the free recall test.

## 5.3.2 Results

### 5.3.2.1 Galvanic skin response (GSR)

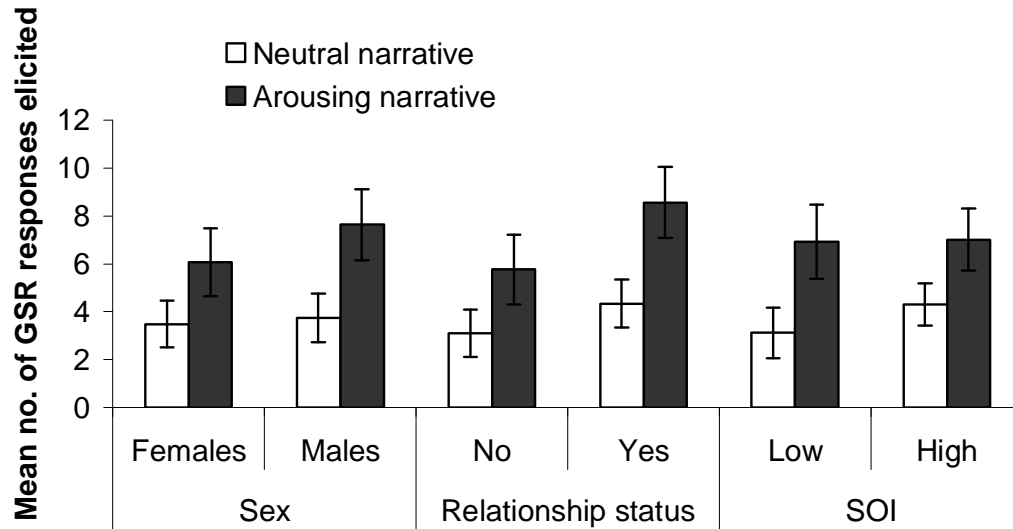
#### 5.5.1.1 Mean number of GSR responses elicited by both narratives

Reliability for SOI scores was calculated separately for males and females using Cronbach's Alpha; males  $\alpha = .70$ , females  $\alpha = .87$ . Repeated measures ANOVA was performed with sex, relationship status, and SOI as the between subject factors, Narrative type as the within subjects factor and 'mean number of GSR responses elicited' as the dependent variable. There was no main effects of sex [ $F=.021$ ,  $df=(1,29)$ ,  $p=.887$ ], SOI [ $F=.159$ ,  $df=(1,29)$ ,  $p=.693$ ], and relationship status [ $F=1.492$ ,  $df=(1,29)$ ,  $p=.232$ ]. There was no sex \* SOI interaction [ $F=.141$ ,  $df=(1,29)$ ,  $p=.710$ ], no sex \* relationship status interaction [ $F=.095$ ,  $df=(1,29)$ ,  $p=.760$ ], and no relationship status \* SOI interaction [ $F=.170$ ,  $df=(1,29)$ ,  $p=.683$ ].

There was a significant main effect of narrative type [ $F=17.877$ ,  $df=(1,29)$ ,  $p<.001$ ] with greater GSR response frequency for the AN than the NN, but there was no narrative type \* sex interaction [ $F=.292$ ,  $df=(1,29)$ ,  $p=.593$ ], no narrative type \* relationship status interaction [ $F=.472$ ,  $df=(1,29)$ ,  $p=.497$ ], no narrative type \* SOI interaction [ $F=.455$ ,  $df=(1,29)$ ,  $p=.505$ ], narrative type \* sex \* relationship status interaction [ $F=.131$ ,  $df=(1,29)$ ,  $p=.720$ ], no narrative type \* sex \* SOI interaction [ $F=.021$ ,  $df=(1,29)$ ,  $p=.884$ ], or narrative type \* SOI \* relationship status interaction [ $F=.491$ ,  $df=(1,29)$ ,  $p=.489$ ]. See Figure 5.1



**Figure 5.1** Mean number of GSR responses elicited by Neutral and Arousing narratives. Error bars represent +1/-1 standard error of the mean.



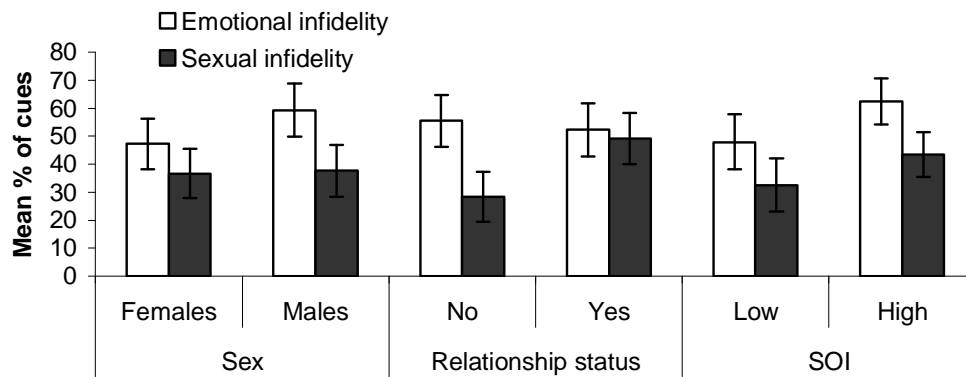
*5.3.2.1.2 Mean percentage of cues to emotional and sexual infidelity that elicited a GSR response*

Focusing specifically on the Arousing Narrative and at the mean % of cues to emotional and sexual infidelity that elicited a GSR response (i.e. excluding the ambiguous cues from analysis); a repeated measures ANOVA was performed with sex, relationship status, and SOI as the between subject factors, ‘cue type’ as the within subjects factor, and ‘mean % of cues that elicited a GSR response’ as the dependent variable. There was a within subjects effect of ‘cue type’ [F= 9.448, df=(1,29), p= .005] with a higher percentage of cues to Emotional infidelity eliciting a GSR response than cues to Sexual infidelity. There was no cue type \* sex interaction [F= 1.366, df=(1,29), p= .252], there was a trend towards a significant cue type \* relationship status interaction [F= 3.822, df=(1,29), p= .060], no cue type \* SOI interaction [F= .003, df=(1,29), p= .955], no cue type \* sex \* relationship status

interaction [ $F= .648$ ,  $df=(1,29)$ ,  $p= .427$ ], no cue type \* sex \* SOI interaction [ $F= 2.129$ ,  $df=(1,29)$ ,  $p= .155$ ], and no cue type \* SOI \* relationship status interaction [ $F= .022$ ,  $df=(1,29)$ ,  $p= .884$ ].

Examining the cue type \* relationship status interaction further, one way ANOVA revealed that there was no difference in responsivity to cues to emotional infidelity between those in a relationship and those not [ $F=.03$ ,  $df=(1,38)$ ,  $p=.863$ ], but there was a significant difference in responsivity to cues to sexual infidelity between those in a relationship and those not [ $F=5.187$ ,  $df=(1,38)$ ,  $p=.029$ ]; in that those in a relationship had higher responsivity. See Figure 5.2

**Figure 5.2** Mean % of cues to emotional and sexual infidelity that elicit a GSR response. Error bars represent +1/-1 standard error of the mean.



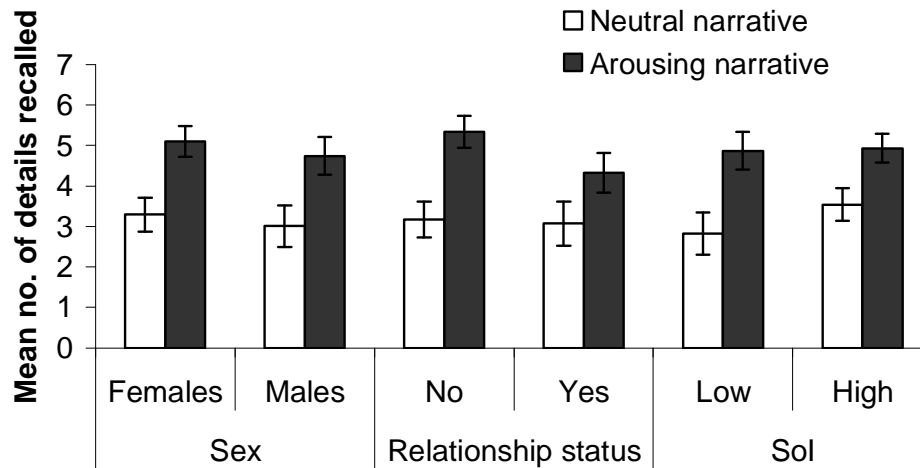
### 5.3.2.2 *Free recall memory*

#### 5.5.2.1 *Mean number of details recalled for narratives*

Repeated measures ANOVA was performed with sex, relationship status, and SOI as the between subject factors, Narrative type as the within subjects factor, and mean number of details recalled as the dependent variable. There was no main effect of sex [ $F=.442$ ,  $df=(1,43)$ ,  $p=.51$ ], relationship status [ $F=.648$ ,  $df=(1,43)$ ,  $p=.425$ ], SOI [ $F=.880$ ,  $df=(1,43)$ ,  $p=.354$ ], no sex \* relationship status interaction [ $F=.1010$ ,  $df=(1,43)$ ,  $p=.320$ ], no sex \* SOI interaction [ $F=.001$ ,  $df=(1,43)$ ,  $p=.973$ ], and no relationship status \* SOI interaction [ $F=.061$ ,  $df=(1,43)$ ,  $p=.807$ ].

There was a significant main effect of narrative type [ $F=24.800$ ,  $df=(1,43)$ ,  $p<.001$ ] with significantly greater memory for the arousing narrative. There was no narrative type \* sex interaction [ $F=.38$ ,  $df=(1,43)$ ,  $p=.541$ ], no narrative type \* relationship status interaction [ $F=.347$ ,  $df=(1,43)$ ,  $p=.559$ ], no narrative type \* SOI interaction [ $F=.012$ ,  $df=(1,43)$ ,  $p=.913$ ], a trend towards a significant narrative type \* sex \* relationship status interaction [ $F=3.310$ ,  $df=(1,43)$ ,  $p=.076$ ], no narrative type \* sex \* SOI interaction [ $F=.2342$ ,  $df=(1,43)$ ,  $p=.133$ ], and a significant narrative type \* SOI \* relationship status interaction [ $F=4.511$ ,  $df=(1,43)$ ,  $p=.039$ ].

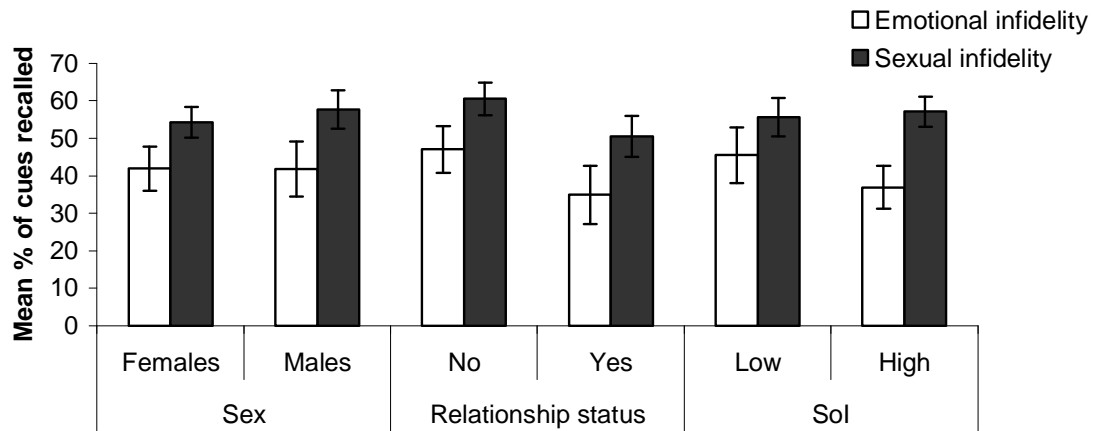
**Figure 5.3** Comparing mean number of details recalled between Neutral and Arousing narrative. Error bars represent +1/-1 standard error of the mean.



5.3.2.2.2 *Mean percentage recall of cues to infidelity.*

Looking specifically at the AN and at recall for cues to emotional and sexual infidelity; a repeated measures ANOVA was performed with sex, relationship status, and SOI as the between subject factors, cue type as the within subjects factor, and mean % of cues recalled as the dependent variable. There was a within subjects effect of cue type [ $F=7.182$ ,  $df=(1,30)$ ,  $p=.01$ ], with greater memory for the cues to sexual infidelity, there was no cue type \* sex interaction [ $F=1.11$ ,  $df=(1,43)$ ,  $p=.298$ ], no cue type \* relationship status interaction [ $F=.207$ ,  $df=(1,43)$ ,  $p=.651$ ], no cue type \* SOI interaction [ $F=.007$ ,  $df=(1,43)$ ,  $p=.935$ ], a marginally significant cue type \* sex \* relationship status interaction [ $F=3.496$ ,  $df=(1,43)$ ,  $p=.068$ ], no cue type \* sex \* SOI interaction [ $F=2.337$ ,  $df=(1,43)$ ,  $p=.134$ ], there was a significant cue type \* SOI \* relationship status interaction [ $F=5.176$ ,  $df=(1,43)$ ,  $p=.028$ ] interaction. See Figures 5.4, 5.5 and 5.6.

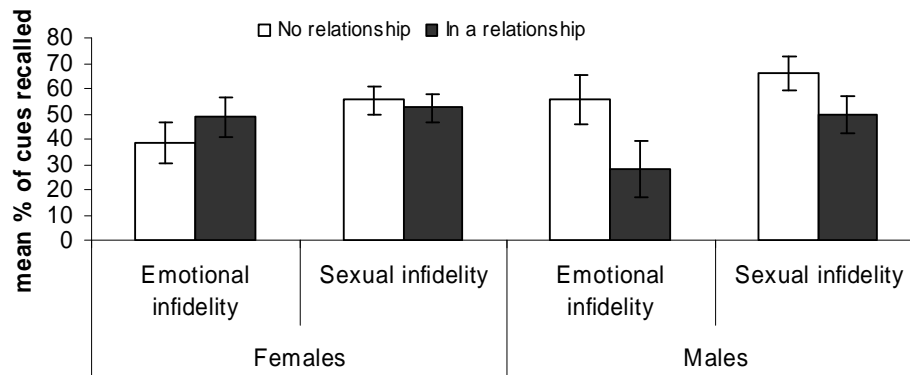
**Figure 5.4** Mean % recall of cues to Emotional and Sexual infidelity. Error bars represent +1/-1 standard error of the mean.



5.3.2.2.3 *Recall of infidelity cues: cue type \* sex \* relationship status interaction*

As can be deduced from Figure 5.5, the trend towards a significant interaction is due to memory scores for cues to Emotional infidelity: females ‘in a relationship’ have a higher score than those ‘not in a relationship’, whereas; males ‘not in a relationship’ have higher memory scores than males ‘in a relationship’.

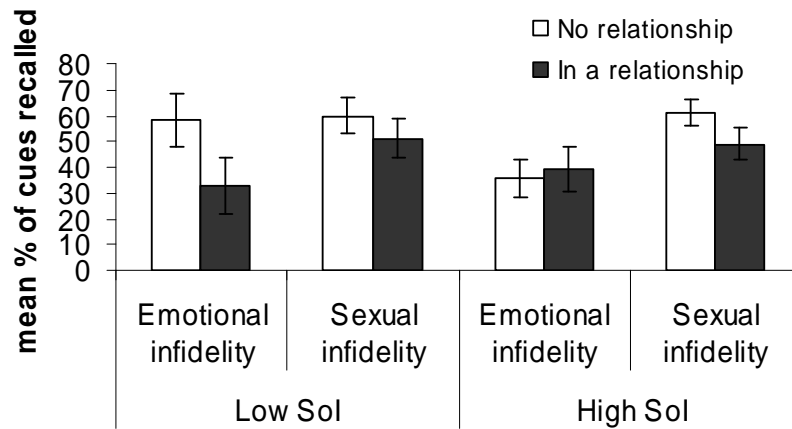
**Figure 5.5** Mean % recall of cues to Emotional and Sexual infidelity. Error bars represent +1/-1 standard error of the mean.



5.3.2.2.4 *Recall of infidelity cues: cue type \* SOI \* relationship status interaction*

This interaction is due to memory for cues to emotional infidelity: those of ‘High SOI’ ‘in a relationship’ have a marginally better score than those of ‘High SOI’ ‘not in a relationship’, whereas; those of ‘Low SOI’ ‘not in a relationship’ have a higher score than ‘Low SOI’ ‘in a relationship’.

**Figure 5.6** Free recall memory for cues to Emotional and Sexual infidelity: cue type \* SOI \* Relationship status interaction. Error bars represent +1/-1 standard error of the mean.



### 5.3.2.3 Free recall memory and GSR correlations

#### 5.3.2.3.1 Arousing narrative

In order to investigate whether autonomic nervous arousal correlates with memory, the ‘total number of GSR responses’ and the ‘average amplitude of GSR responses’ for the AN was correlated with total memory for the arousing narrative using Spearman’s rho (this test was employed to control for the effects of outliers and due to the relatively small sample size). Memory for the Arousing narrative did not correlate with the total number of GSR responses [ $r=-.073$ ,  $N= 42$ ,  $p=.646$ ].

#### 5.3.2.3.2 *Infidelity cues*

'GSR response frequency' and 'average magnitude' scores to cues to Emotional infidelity were correlated with memory for cues to emotional infidelity using Spearman's rho.

Memory for cues to emotional infidelity did not correlate with GSR 'response frequency' [ $r = .071$ ,  $N=42$ ,  $p=.653$ ]. 'GSR response frequency' to cues to Sexual infidelity, was correlated with memory for cues to Sexual infidelity using Spearman's rho. Memory for cues to Sexual infidelity was not significantly negatively correlated with GSR 'response frequency' [ $r = -.265$ ,  $N=42$ ,  $p=.09$ ].

### 5.3.3 Discussion

#### 5.3.3.1 *Arousing and neutral narratives*

The fact that the AN elicited more GSR responses than the NN, and that participants had enhanced memory for this narrative, suggests that participants were emotionally aroused by the infidelity cues and this may have enhanced memory consolidation for these cues.

However, a direct correlation between memory and GSR for the AN was not evident.

There was an interaction involving memory for the AN, relationship status, and sex. Males 'not in a relationship' had better memory for the AN than females 'not in a relationship', but for those 'in a relationship' females outscored males. Being in a relationship may intensify reactions to infidelity cues as they are more easily imaginable and feel more real for females but not for males. The interaction however, was only marginally significant and future research with a larger sample size will be required before its validity can be ascertained. An interaction involving SOI and relationship status concerning memory for the NN was also found. This was due to High SOI individuals 'not in a relationship'



having greater memory than High SOI ‘in a relationship’. It is not clear why this finding may have emerged, and may be an artifact of a small sample size.

#### 5.3.3.2 *Cues to emotional and sexual infidelity*

The innate module view of sexual jealousy was not supported. Females did not have enhanced GSR activity or memory for emotional infidelity cues in comparison to sexual infidelity cues. Likewise, males did not display enhanced GSR activity or memory for sexual infidelity cues in comparison to emotional infidelity cues. However, participants did elicit greater GSR responsivity to emotional rather than sexual infidelity cues.

Contrastingly, participants displayed greater memory for cues to *sexual* compared to *emotional* infidelity. This finding seems rather contradictory as one would assume the cue type that elicited greater GSR responsivity is the more emotionally arousing cue and thus would be remembered better.

The Low SOI group did not differ from the High SOI group for GSR activity or memory for cues to either emotional or sexual infidelity. Examining relationship status revealed a key finding; those in a committed relationship showed enhanced GSR responsivity for cues to sexual infidelity compared with those not in a committed relationship. This finding is congruent with Harris (2000) who found that females with experience of a committed relationship showed greater blood pressure increases when imagining a mate engaging in sexual infidelity than females without such relationship experience. Harris (2003b) also reported that greater experience with committed relationships was positively associated with greater sexual jealousy over a mate’s actual infidelity for both sexes. It seems that jealousy regarding sexual infidelity may be amplified either via currently being in a relationship or with relationship experience, and this may be more true for females than for

males. This finding highlights the importance of contextual variables (in this case relationship status) in the manifestation of jealousy between two people in a relationship.

### *5.6.3 Sociosexual Orientation Inventory (SOI)*

This study predicted that Low SOI individuals would display greater GSR activity and memory both forms of infidelity cues as they attach greater importance to inter-personal bonds within a relationship. These predictions were not supported and are congruent with Harris's (2003b) failure to find an association between SOI and distress regarding emotional and sexual aspects of infidelity. Taken together they results suggest the SOI may not be a useful tool in elucidating what type of personality variables may differentially affect arousal and memory for cues to infidelity.

#### *5.3.3.4 Relationship status*

Participants currently in a committed relationship showed enhanced GSR responsivity for cues to sexual infidelity compared with those not in a committed relationship. This is the most interesting finding of the study, and together with Harris (2000 and 2003b; who found a similar effect in females), elucidates that experience of committed relationships intensifies feelings of jealousy regarding cues to sexual infidelity. Relationship status differentially affected memory for the AN for males and females. Males 'not in relationship' outscored females 'not in a relationship' but this pattern was reversed for males and females 'in a relationship'. This interaction was only marginally significant, therefore further research is required before it can be determined a robust and replicable phenomenon.

#### *5.3.3.5 Revising the innate module view of jealousy*

The study did not find any support for the ‘innate module’ view of sexual jealousy, with no evidence supporting the contention that males and females are genetically predisposed to be upset by different forms of infidelity. Support for the Socio-Cognitive viewpoint was found with those ‘in a relationship’ displaying greater GSR responsivity to cues to sexual infidelity. The finding suggests that highlights the importance of contextual variables and how they might interact with more hardwired sex differences. Future research should look to relate memory and emotional arousal to specific cues, with subjective perception of whether those cues are cues to sexual or emotional infidelity. The factors that influence jealous feelings and behaviour are multifaceted and more work will be needed to untangle these factors.

#### *5.3.3.6 Are memory and emotional arousal functioning in an adaptive manner?*

The fact that the AN elicited greater GSR responsivity and was also remembered better than the NN suggests that physiological arousal may be facilitating memory consolidation of emotional events. This is predicted by an evolutionary view of emotions as functional adaptations facilitating survival and reproduction. It is clearly adaptive for both males and females to find cues to infidelity emotionally arousing and memorable as this will increase the likelihood of taking appropriate action.

### 5.3.3.7 *Conclusion*

The results of the study revealed that females did not have enhanced GSR activity or memory for emotional infidelity cues in comparison to sexual infidelity cues. Likewise, males did not display enhanced GSR activity or memory for sexual infidelity cues in comparison to emotional infidelity cues. The key finding of this study was that participants, currently in a committed relationship, elicited greater GSR activity in response to cues to sexual infidelity. However, GSR activity in response to cues to sexual and emotional infidelity did not correlate with memory for those cues. These results do not support the innate module view of relationship jealousy and suggest contextual variables such as relationship status may be more important in determining what type of infidelity males and females find more threatening.

## **Chapter 6 Investigating ability at detecting ‘liars’ and recognition memory for the faces of ‘liars’**

### **Abstract**

#### *Aims:*

1. To investigate whether individuals show enhanced ability at detecting ‘liars’ from ‘truth-tellers’, and enhanced memory for the faces of ‘liars’ than the faces of ‘truth-tellers’.
2. To investigate whether females outperform males at detecting ‘liars’ and show enhanced memory for the faces of ‘liars’.
3. To investigate whether level of autistic traits correlates negatively with lie detection and memory performance for ‘lying stimuli’.

#### *Methods*

Forty four healthy participants (23 females) viewed a series of video clips, half of which depicted footage of individuals lying, half of which depicted individuals telling the truth. Participants rated whether they thought the individual in each clip was lying using a Likert type rating scale. Participants then completed the Autism Spectrum Quotient (AQ) questionnaire, before receiving a surprise recognition memory test of individuals depicted in the video clips.

#### *Results*

Participants did not show enhanced performance at detecting ‘liars’ from ‘truth-tellers’. Participants also did not show enhanced recognition memory for the faces of ‘liars’. Females, but not males, showed significant positive correlation between level of autistic traits and success at detecting ‘liars’, opposite to the predicted outcome.

#### *Conclusion*

The surprise finding for females that level of autistic traits was positively correlated with success at detecting ‘liars’ was related to other literature which showing enhanced lie detection performance in individuals with impaired language capacities.

## 6.1 Introduction

As discussed in depth in Chapter 1, research suggests that our ancestors must have been capable of detecting and remembering cheaters so that appropriate action could be taken against them (e.g. Cosmides & Tooby 1992). Studies have also shown that humans may be capable of detecting subtle visual cues that ‘cheaters’ faces give off. In fact, a review of the lie detection literature (DePaulo et al. 2003) revealed ‘liars’ in laboratory studies tend to fidget more, dilate their pupils more, have greater tension in their voice and press their lips together more, than truth-tellers. Ekman & O’Sullivan (1991) showed that American Secret service agents had better than chance probability at detecting liars from a series of video clips showing an equal number of ‘liars’ and ‘truth-tellers’.

More recent neuropsychological evidence suggests that there may be a specific module in the brain that deals with ‘social contract’ situations. Stone et al. (2002) found a patient with damage to the orbitofrontal cortex, temporal pole, and amygdala showed impaired social contract reasoning (e.g. if you take the benefit you must satisfy the requirement). The authors concluded that this finding suggests that information about the social world is processed separately and differently than other types of information.

### 6.1.1 *The social brain and autistic traits*

Autism is a developmental disorder typified by an acute deficit in communication and social skills (e.g. lack of eye contact), language (e.g. verbal fluency) and imagination (Baron Cohen 2000a). Research has shown that when presented with a series of photographic images depicting various emotions, individuals with Asperger’s syndrome (a condition characterised by an average or above average IQ coupled with autistic traits) had

great difficulty reading complex emotions (such as scheming, admiration and interest), as they required reading information from the eyes (Baron Cohen 1997).

However, a strong body of research prompted by Wing (1988) contends that all individuals fall on a continuum regarding autistic traits; with autism on one end of the continuum, gradually fading into the normal population and towards individuals with highly adept social communication skills. For example, Wakabayashi, Baron-Cohen, Wheelright & Tojo (2006) found a normal distribution of altruistic traits (as measured by the Autism Spectrum Quotient questionnaire), in both a UK and Japanese sample. More recently Wakabayashi et al. (2006) have proposed that autistic traits may represent a sixth dimension of personality in addition to the 'Big 5' personality dimensions (Goldberg 1993). Considering the above it is possible that individuals with a high level of autistic traits may find it more difficult at detecting 'liars' than individuals lower in terms of autistic traits, as they may find it more difficult to read the facial expressions of, and emotional information (in the form of micro expressions) that is displayed in, individuals when they lie. This study will also examine this possibility.

### *6.1.2 Sex differences*

It has also been suggested that the male brain more closely resembles an 'autistic brain' than the female brain (Baron Cohen 1999). In a review of the relevant literature Baron Cohen (1999) outlined how males are better in spatial tasks but slower to develop language than females; and people with autism are superior to normal individuals on spatial tasks, while slower than normal individuals to develop language. Additionally, females are faster to develop socially, and in terms of language ability, and have superior mind reading

ability than normal males; and people with autism are even more delayed in social and language development, and have even more severe deficiencies at mind reading.

Baron Cohen (1999) also outlined the anatomical evidence in support of this theory.

Physiologically, females typically have a larger corpus callosum than males (which is thought to be partly responsible for their superior language abilities) and autistic individuals have an even smaller one.

If this theory is true, i.e. that males possess more autistic traits than females, then one might expect females to out perform males in reading emotional information from the faces of individuals who are lying. This prediction will also be tested in this study.

### *6.1.3 Current study*

This proposed study aims to follow on from studies that have used actual images of individuals in the act of deception, and is primarily interested in whether individuals will have enhanced memory for the faces of 'liars' compared to the faces or 'truth-tellers'. Unlike Yamagishi et al. (2003) however, this study will use video clips of individuals either actually telling the truth or lying, as opposed to an image of individuals as they cheat in a prisoner's dilemma game. The method should offer greater potential for the liars to emit micro-expressions signalling their deceit, as a video clip will convey more information than a static photographic image. The video clips will be created from individuals who are taking part in a card game with an experimenter. Half of the video clips that will be presented to participants will be of individuals lying; the other half will consist of individuals telling the truth.



These stimuli will be then presented to participants who will be asked to rate on a Likert scale of whether they think the individuals in the video clips are lying or telling the truth. Twenty minutes following presentation of the video clips participants are to receive a recognition memory test consisting of still images of the individuals presented in the video clips and an equal number of age and sex matched controls.

This study is also interested in whether autistic traits correlate with performance at detecting and remembering the faces of 'liars'. Participants will complete the Autism Spectrum Quotient questionnaire (Baron Cohen, Wheelwright, Skinner, Martin & Clubley 2001) and scores on this will be correlated with 'lying' ratings of the stimuli (i.e. participants' ratings of whether they thought faces were lying or not) and recognition memory performance for the stimuli. This study will also examine the possibility that females may be more adept at reading social information from faces and thus be better than males at detecting and remembering the faces of liars. Previous research suggests that the ability to detect liars accurately from individuals not lying is often very difficult. For example, DePaulo & Pfeifer (1986) and Kraut & Poe (1980) both failed to show enhanced lie detection ability in individuals with an occupational interest in accurately detecting liars. However, previous research consistently reveals large individual differences in lie detection ability (Ekman & O' Sullivan 1991); and as no known research has employed the AQ questionnaire to relate autistic traits with lie detection performance; the results of this study will make a novel contribution to the literature on lie detection.

#### *6.1.4 Predictions*

- 1) Participants will have enhanced memory for the faces of 'liars' than the faces of 'truth-tellers'.
- 2) Participants high in autistic traits will have diminished performance at detecting 'liars' and will have decreased memory for the faces of 'liars' than those low in autistic traits.
- 3) Females will have enhanced performance at detecting 'liars', and will have enhanced memory for the faces of 'liars' than males.

## **6.2 Methods**

### *6.2.1 Participants*

Twenty three females and twenty one males were recruited from the Glasgow Science Centre to take part in this study. This sample size was chosen using power analysis. Research has found a recognition memory bias for the faces of 'cheaters' with an effect size of 0.79 (Mealy 1996). This effect size was entered into a Power analysis software program (GPower™), in which Alpha was set at .05, and power at .8. This program computed a total sample size of 42 participants. Ethical approval to carry out this study was granted by the University of Stirling Department of Psychology Ethics committee. An application with a detailed description of the study was submitted to this committee detailing the full aims and methodology of the proposed research. This committee made their decision to approve this study after careful analysis of the application. The Glasgow Science Centre is an interactive science exhibition centre, which is geared towards being educational and entertaining and attracts a wide cross section of the community. The centre provided a suitably equipped room for which to recruit and test participants. The

mean age of males in the sample was 26.9 years (SD=12.03; range=17-66 years), and the mean age of females was 33.86 years (SD=15.39; range=17- 70 years).

### 6.2.2 *Creating the video stimuli*

Sixteen males and seventeen females from the University of Stirling student population were recruited (using monetary reward of £5 as incentive) in order to create the stimuli for use in this study. The mean age for females in this sample was 20.61 years (SD = 1.4; range =18-24 years). The mean age for males in this sample was 20.2 years (SD = 1.35; range =18-23 years). All students recruited for this phase of the study were Caucasian, as the inclusion of 'other race' faces may make the stimuli more memorable for participants in the recognition memory phase of the study. These participants were instructed that the study was interested in how successful the 'lie detector' (i.e. a Galvanic skin response/GSR recorder) is at detecting lies, and would involve them participating in a card game, which would be video taped to use as stimuli in future research. Participants were also informed that if they could lie successfully (i.e. without the experimenter being able to tell from their GSR when exactly during the course of the game they had lied) that they would win £5. This monetary incentive to 'lie successfully' was an extra incentive given to participants in order to attempt to make the lie (and thus the video clip of the lie) ecologically valid. Most 'real world' lies are made in order to achieve a benefit while at the same time taking the risk of being found out on the lie. Therefore, there is both pressure on the 'liar' and also a possible reward involved if her or she is successful. This study attempts to simulate both these factors.

Individuals were informed of the details of the card game before signing a consent form.

Individuals were then presented with a playing card from a deck of 10. The experimenter,

however, did not view the card. The experimenter then asked the participant to write down on a piece of paper (provided) the name of the card and to remember it. The experimenter then put the card back in the deck and shuffled all the cards. Each card was then presented, one at a time to the participant. At each presentation the participant was asked “is this your card?” Each participant was informed before hand to answer “No, I am sure this is not my card”, to each card presented, including the one *that was* theirs. Participants were instructed to make their response to each card directly into the video camera, which was set to record for the duration of the task. Each participant’s GSR was recorded for the duration of this procedure. GSR cuffs were applied to participants immediately after they were fully instructed about the study and were removed after completion of the card task (see Chapter 5 for detailed description of GSR cuff application and methodology). Each time a participant responded “no I am sure this is not my card”, their GSR was ‘event marked’ so the experimenter could determine the GSR activity in response to each card presentation. The GSR recording in this study served as a ruse to add ‘psychological pressure’ to the participant when they were performing the task, as results of the GSR recording were not analysed. In order to identify which video clip the participants lied on the participant displayed the sheet of paper revealing their card. If this card was, for example, the 7<sup>th</sup> card presented to the participant, then the 7<sup>th</sup> video clip would be the one in which the participant was lying.

Therefore, each participant yielded 10 instances (one per card) of looking into the camera and saying “no I am sure this is not my card”, one of which was a lie. When the card game ended the GSR finger cuffs were removed. The experimenter then tried to deduce from the GSR readings on what trial the participant lied, and thus, which card was ‘the participant’s card’. Regardless of whether the experimenter was successful at detecting the participant’s

lie, each participant received the £5 reward, and was fully debriefed as to the nature of the study, and the future research in which the video clips would be employed.

The video footage for each participant was divided into 10 segments, using Liquid 6™ video editing software. Each segment was of between 5.5 and 6 seconds duration and consisted of the experimenter asking (from behind the camera and out of view) the participant “is this your card?” and the participant replying “no I am sure this is not my card”. The footage was of the participant’s head (from the shoulders up), with a blue screen as a background. For each participant, a video clip of when they lied and a video clip of when they were telling the truth were extracted from the video footage using Liquid 6™ video editing software. Each participant produced nine ‘truthful’ clips and one ‘lying’ clip. The truthful clip that most closely matched the ‘lying’ clip in terms of the length of time it took the participant to state “no I am sure this is not my card”. Therefore a total of 33 clips of individuals telling the truth and 33 clips of individuals lying were produced. Two different ‘video reels’ were created, one of which showed 17 clips of individuals lying and 16 of individuals telling the truth, and the second which showed those same 17 individuals (who were lying in the first reel) telling the truth, and those same 16 individuals (who were telling the truth in the first reel) lying. Therefore each ‘reel’ was automatically matched for distinctiveness (memorableness), sex, and age of the stimuli.

Each reel was converted from Liquid 6™ video file format into a Windows Media Player (WMP) compatible file, which could thus be played on WMP™. Each video clip was positioned, one after the other, with an 8 second gap between each clip. This 8 second space between each clip was to allow participants time to make a decision as to whether they thought the individual in the clip was lying or not. Eight seconds was deemed an appropriate time as the study was interested in the participants’ ‘gut’ or immediate reaction

to the clip, and this 8 second time frame meant participants were required to quickly make up their mind and rate whether they thought the person was lying or not (on a rating scale provided) before the next clip was shown. The order of clips within both 'reel 1' and 'reel 2' was randomised using a random sequence generator ([www.random.org](http://www.random.org)) for each participant.

For the study proper, participants were provided with Likert rating scales ranging from 1 to 6 (for each video clip) printed on A4 sized paper. A rating of '1' indicated the participant thought the individual in the video clip was 'definitely *telling the truth*', a rating of '6' indicated the participant thought the individual in the video clip was 'definitely *lying*'.

### 6.2.3 *Recognition memory test*

For the recognition memory test, still images of the 33 individuals that made up the stimuli were produced. The images were taken of these individuals immediately before they participated in the card game. Also a separate batch of thirty images of 15 males and 15 females was produced. These images were to be used as control images or 'lures' in the recognition memory test. The individuals used to create these images were recruited using course credit reward and were matched for age with the actual stimuli. The mean age of males was 20.12 years (SD= 1.5; range=18-24 years). The mean age of females was 20.02 years (SD=1.41; range=18-23 years). The order of presentation of the images was randomised for each participant using a random sequence generator ([www.random.org](http://www.random.org)). The set of stimuli was presented on a laptop computer screen using PowerPoint™ presentation software. Each participant viewed one image at a time and navigated their way from one image to the next using the 'right arrow' key on the computer. Participants were asked to rate whether they remembered each image using a Likert scale.

The Likert rating scales ranged from 1 to 6 (for each image) printed on A4 sized paper. A rating of '1' indicated the participant thought that they 'definitely *do not remember*' the image, a rating of '6' indicated the participant thought they 'definitely *do remember*' the image.

#### 6.2.4 *The Autism spectrum quotient (AQ) questionnaire*

The AQ model assumes autistic traits lie on a continuum (Baron-Cohen 1995; Wing 1981). In support of this assumption is recent research by Wakabayashi et al. (in Press), showing a normal distribution of autistic traits in nonclinical UK and Japanese samples. The AQ consists of 50 items, assessing 5 dimensions: 'social skill', 'attention switching', 'attention to detail', 'communication' & 'imagination' (Baron Cohen et al. 2001). The AQ also yields a total AQ score, with a *higher score indicating a higher number of autistic traits*. This study is particularly interested in 'total AQ' score. Additionally, an AQ 'social brain' score was also computed by adding the 'social skill' and 'communication' items together. Any deficiency in reading social information (such as facial micro-expressions) will be most accurately reflected by the 'social skill' and 'communication' items, and it is ability at reading minute facial expressions that is most likely to correlate with ability at accurately detecting liars.

The population mean for total AQ score is 15.4 (SD=5.7) for 'normal' females; 17.8 (SD=6.8) for 'normal males'; and 35.8 (SD=6.5) for Asperger's syndrome sufferers (Baron Cohen et al. 2001). The AQ is reproduced in Appendix 17.

### 6.2.5 Procedure

Participants were informed of the nature of the study and then signed the consent form to agree to take part. Participants were randomly presented (using a random sequence generator found at [www.random.org](http://www.random.org)) with either 'reel 1' or 'reel 2'. They were provided with headphones so as to clearly hear the voices of the stimuli. Participants were informed that there would be a gap of 8 seconds between each clip, in which they would rate whether they thought the person in the clip was lying or not. Participants were provided with a pen and asked to circle on a series of rating scales whether they thought the individual was lying or not.

It was explained to participants that the clips they were about to see involved an individual taking part in a card game with an experimenter. For each clip the individual will say "no I am sure this is not my card". For some of these clips the individual saying this will be telling the truth (it is not actually their card), some individuals, however, are lying (it is actually their card). Participants are informed the reason they are lying is to deceive the experimenter in order to win £5. This set of instructions is used to implant into the participants mind that some of the individuals they are about to see are being deceitful in order to win money. This information should 'activate' the cheat detection module proposed by Cosmides & Tooby (1992).

Immediately after viewing the stimuli participants were asked to complete a straightforward demographics questionnaire followed by the AQ. Following this, participants completed a surprise recognition memory test involving images of individuals in the video clips.



### 6.2.6 *Study design*

Half the participants tested in this study viewed the ‘reel 1’ sequence of video clips, these individuals were categorised as ‘*study group 1*’. The other half viewed ‘reel 2’ and were categorised as ‘*study group 2*’. Therefore, the design of this study was a 2 (sex: male and female) \* 2 (study group: ‘study group 1’ and ‘study group 2’) \* 2 (type of stimuli: ‘lying stimuli’ and ‘truth-telling’ stimuli) design.

## 6.3 **Results**

### 6.3.1 *Potentially confounding variables*

#### 6.3.1.1 *Age*

A univariate ANOVA with ‘study group’ and ‘sex’ as the between subjects factor and ‘age’ as the dependent variable revealed no significant between subject differences in age for ‘sex’ [ $F(1,40)=2.604$ ,  $p=.115$ ] or study group [ $F(1,40)=2.1950$ ,  $p=.171$ ]. Mean age for ‘study group 1’ was 33.5 years (SD= 16.129; range =17-70 years). Mean for ‘study group 2’ was 27.55 years (SD= 11.603; range = 17-52 years). See ‘Participants’ section in ‘Materials & Methods’ for descriptive age data for males and females.

### 6.3.2 Lie detection performance

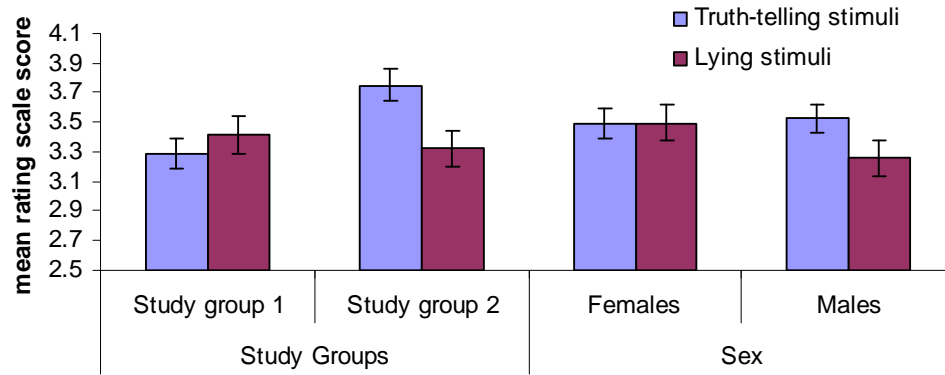
*A rating of '1' indicates participants thought individuals in the clips were definitely telling the truth. A rating of '6' indicates participants thought individuals in the clips were definitely lying.*

Kendall's W (i.e. coefficient of concordance) was employed to determine the agreement among participants concerning their ratings of 'lying' stimuli and 'truth-telling' stimuli. Kendall's coefficient (W) ranges from 0 to 1, with 0 indicating complete disagreement among raters, and 1 indicating complete agreement among raters. For 'study group 1' Kendall's W = .17 for ratings of 'lying stimuli, and Kendall's W = .16 for ratings of 'truth-telling' stimuli. For 'study group 2' Kendall's W = .2 for ratings of 'lying stimuli, and Kendall's W = .16 for ratings of 'truth-telling' stimuli.

A repeated measures ANOVA was performed with 'study group' and 'sex' as between subject factors and 'lying ratings' for stimuli (i.e. 'lying' stimuli vs. 'truth-telling' stimuli) as the dependent variable. The analysis revealed no main effect of 'type of stimuli' (i.e. lying vs. truth-telling) on 'lying ratings' [ $F(1,40)= 2.816, p=.101$ ]. There was also no main effect of 'study group' [ $F(1,40)= 2.671, p=.110$ ], or 'sex' [ $F(1,40)=1.773, p=.191$ ] on 'lying ratings'.

The analysis also revealed no 'type of stimuli' \* 'sex' interaction on 'lying ratings' [ $F(1,40)= .818, p=.371$ ]. See Figure 6.1.

**Figure 6.1** Lying ratings for stimuli. Error bars represent +1/-1 standard error of the mean.



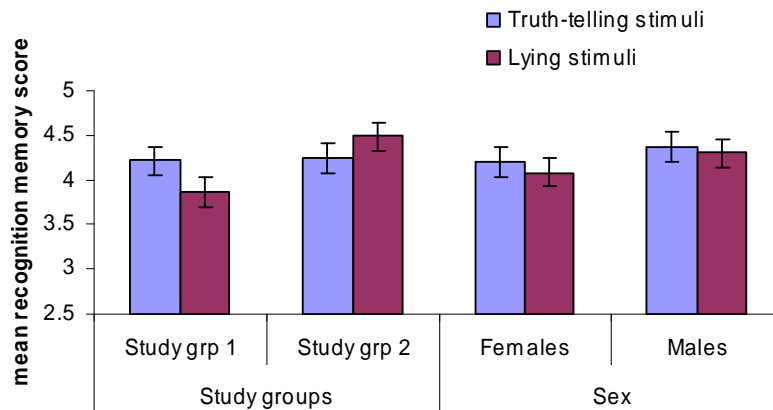
### 6.3.3 Recognition memory for stimuli

*A rating of '1' indicates participants thought they definitely remembered the image from the video clips presented to them. A rating of '6' indicates participants thought they definitely did not remember the image from the video clips presented to them.*

A repeated measures ANOVA was performed on recognition memory scores with 'study group' and 'sex' entered as between subject factors and recognition memory for stimuli (i.e. lying stimuli vs. truth-telling stimuli) entered as the dependent variable. The analysis revealed no main effect of 'type of stimuli' on recognition memory scores [ $F(1,40) = .575$ ,  $p = .453$ ]. There was a significant main effect of 'study group' [ $F(1,40) = 4.466$ ,  $p = .041$ ], but no significant main effect of 'sex' [ $F(1,40) = .678$ ,  $p = .415$ ] on recognition memory scores.

The analysis also revealed no ‘type of stimuli’ \* ‘sex’ interaction on recognition memory scores [ $F(1,40)=.001, p=.983$ ]. See Figure 6.2.

**Figure 6.2** Recognition memory for stimuli. Error bars represent +1/-1 standard error of the mean.



### 6.3.4 Correlating the Autism Spectrum Quotient with lie detection performance

#### 6.3.4.1 Preliminary analysis

A Shapiro Wilks test was performed on ‘AQ total’, ‘lying ratings’, and ‘recognition memory’ scores (for both males & females) to reveal if they were normally distributed (the Shapiro Wilks test is recommended for sample sizes under two thousand cases (Brace, Kemp & Snelgar, 2003)). The analysis revealed that ‘recognition memory’ scores for ‘truth-telling stimuli was not normally distributed in males [ $SW=.897, df=21, p=.031$ ], and ‘lying ratings’ for ‘truth-telling’ stimuli was marginally normally distributed in females [ $SW=.925, df=23, p=.087$ ]. Therefore, a Spearman’s rank correlation was used to correlate the AQ total score with ‘lying ratings’ and recognition memory performance. See Tables

6.1 & 6.2 for results of analysis. Internal reliability for each of the subscales of AQ was calculated using Cronbach's Alpha. The results of this analysis are as follows: for AQ social skills  $\alpha = .577$ ; for AQ attention switching  $\alpha = .375$ ; for AQ attention to detail  $\alpha = .572$ ; for AQ communication  $\alpha = .517$ ; for AQ imagination  $\alpha = .272$ ; for AQ total  $\alpha = .62$ ; for AQ social brain  $\alpha = .47$ .

One sample t-tests were employed to compare the mean total AQ score for males and females with their respective population means (as described in *Methods & Materials*). The analysis revealed no difference for these means for males [ $t = -.293$ ,  $df = 20$ ,  $p = .773$ ] or females [ $t = 1.485$ ,  $df = 22$ ,  $p = .152$ ].

6.3.4.2 Correlating AQ with lying ratings

As we are conducting multiple tests there is an increased probability of producing a Type I error. In order to control for this possibility the probability value was set at .01. See Table 6.1 for results of AQ and lying rating correlations.

**Table 6.1** The relationship of AQ with Lying ratings

AQ→			AQ SS	AQ AS	AQ C	AQ I	AQ AtD	AQ T	AQ SB
			M mean=2.38 SD=2.22 F mean=2.22, SD=1.8	M mean=5.0, SD=2.55 F mean=4.87, SD=2.68	M mean=2.33 SD=1.742 F mean=2.57, SD=1.62	M mean=3.24, SD=2.189 F mean=2.48, SD=2.02	M mean=4.38, SD=1.717 F mean=5.09, SD=2.74	M mean=17.3, SD=7.31 F mean=17.21, SD=5.86	M mean=4.71, SD=3.43 F mean=4.78, SD=2.53
Lying ratings	Lying Stimuli	M <sub>r</sub>	.003	-.481	.113	-.112	-.104	-.125	.102
		p	.990	.027	.626	.630	.653	.589	.661
		F <sub>r</sub>	.249	.391	.468	.234	.109	.418	.523
		p	.252	.065	.024	.283	.620	.047	.010*
	Truth- telling Stimuli	M <sub>r</sub>	.043	-.404	-.513	-.099	.009	-.287	-.281
		p	.852	.069	.017	.669	.970	.208	.218
		F <sub>r</sub>	-.100	-.004	-.118	-.382	-.121	-.169	-.192
		p	.650	.986	.592	.072	.583	.441	.380

**Key.** SD = standard deviation. M = males. F= females. AQ SS = AQ 'social skills'. AQ AS= AQ 'attention switching'. AQ I= AQ 'imagination'. AQ AtD = AQ 'attention to detail'. AQ T = AQ 'total'. AQ SB = AQ 'social brain'.

### 6.3.4.3 Correlating AQ with recognition memory

As we are conducting multiple tests there is an increased probability of producing a Type I error. In order to control for this possibility the probability value was set at .01

**Table 6.2** The relationship of AQ with recognition memory scores

AQ→				AQ SS	AQ AS	AQ C	AQ I	AQ AtD	AQ T	AQ SB
		M	F	mean=2.38 SD=2.22	mean=5.0, SD=2.55	mean=2.33 SD=1.742	mean=3.24, SD=2.189	mean=4.38, SD=1.717	mean=17.3, SD=7.31	mean=4.71, SD=3.43
RM scores	Lying Stimuli	M	r	.022	.051	.037	-.074	.106	.036	.033
			p	.926	.825	.874	.748	.649	.878	.888
		F	r	.186	.126	.026	-.207	.071	.173	.130
			p	.395	.567	.907	.344	.748	.430	.555
	Truth-telling Stimuli	M	r	.046	.193	.012	.103	.280	.181	.036
			p	.843	.401	.960	.657	.218	.432	.878
		F	r	.431	.111	-.117	-.149	-.045	.223	.222
			p	.040	.613	.595	.496	.838	.305	.309

**Key.** SD = standard deviation. M = males. F= females. AQ SS = AQ 'social skills'. AQ AS= AQ 'attention switching'. AQ I = AQ 'imagination'. AQ AtD = AQ 'attention to detail'. AQ T = AQ 'total'. AQ SB = AQ 'social brain'.

### 6.3.5 The relationship between 'lying ratings' of stimuli and recognition memory

#### 6.3.5.1 Preliminary analysis

A Shapiro Wilks test was employed to determine if the 'lying rating' scores and recognition memory scores (for 'lying' and 'truth-telling' stimuli) were normally distributed for both males and females. The analysis revealed all these variables were normally distributed [all  $p > .114$ ,  $< .93$ ]. Therefore, a Pearson's product moment correlation was used to correlate this memory scores with 'lying ratings'. See table 6.3 below for results of analysis.

6.3.5.2 *Lying ratings and recognition memory correlations*

As we are conducting multiple tests there is an increased probability of producing a Type I error. In order to control for this possibility the probability value was set at .01.

**Table 6.3** The relationship between ‘lying ratings’ and recognition memory performance for both males and females.

Males → Females ↓		LR for ‘truth- telling’ stimuli	LR for ‘lying stimuli’	RM for ‘truth- telling stimuli	RM for ‘lying stimuli’
LR for ‘truth- telling’ stimuli	R	-	-.071	.072	.138
	p	-	.758	.756	.552
	N	-	21	21	21
LR for ‘lying stimuli’	r	-.117	-	-.283	-.232
	p	.595	-	.213	.311
	N	23	-	21	21
RM for ‘truth- telling stimuli	r	.099	.044	-	.541
	p	.652	.843	-	.011
	N	23	23	-	21
RM for ‘lying stimuli’	r	.288	-.219	.488	-
	p	.182	.315	.018	-
	N	23	23	23	-

**Key:** LR= ‘lying ratings’. RM= ‘recognition memory’. Light grey= female scores. Dark grey = males scores.

The above analysis reveals no correlation between ‘lying ratings’ and recognition memory performance for either ‘lying stimuli’ or ‘truth telling stimuli’.



## 6.4 Discussion

### 6.4.1 *Performance at detecting 'liars'*

Participants could not distinguish 'lying' stimuli from stimuli 'telling the truth'; failing to support the prediction that individuals would be capable of detecting 'liars' from those telling the truth. There was also no sex difference in the ability to detect 'liars'; failing to support the prediction that females would have enhanced performance at detecting liars than males.

The participants' overall inability to detect individuals who are lying from individuals who are telling the truth is not an isolated finding in research in this field. A review of the lie detection literature by Ekman (1996) highlights this fact. The author outlines how performance at detecting liars from non-liars, based on their demeanour (facial expressions, and general body language) is often not much better than chance. DePaulo & Pfeifer (1986), for example, failed to show enhanced lie detecting ability in a sample of American law enforcement officers. This however, is not because 'liars' do not elicit sufficient information; research shows with slow motion replays 80% accuracy in detecting liars is possible (Ekman 1996). Ekman (1996) instead posits a number of reasons individuals are poor lie detectors. One of which is that we tend not to want to catch liars; as being suspicious rather than trusting of individuals may lead to a lower quality of life. Therefore, a general rule of thumb to trust others (regardless of evidence) may develop in individuals. The author also suggests we may unknowingly conspire in the lie as knowing the truth may be too costly. Another suggestion is based on ideas outlined by Goffman (1974) that we are 'courteous' in our social interactions and reluctant to 'take' information that is not 'given' to us. This explanation is directly contrary to the hypothesis outlined in

the introduction which contended that it is adaptive for individuals to be able to detect deception. However, it may be the case that for certain types of minor or 'white' lies it is adaptive for humans to fail to recognise in order to keep inter-personal relationships running smoothly. Nevertheless, it may be adaptive for more serious forms of deception to be detected. It is possible that in this study the 'lie' was not important enough for the individual having to detect it. Future research should aim to increase the incentive to detect a lie, on behalf of the individual attempting to detect to lie. It may be the case that when the benefits of detecting a lie (or deception in general) outweighs the damage to a inter-personal relationship that such detection would incur, that individuals tend to be better at detecting deception. Future research should aim to explore this possibility by manipulating the incentive to the 'lie detector' to detect lies to find whether it enhances detection performance.

#### *6.4.2 Recognition memory*

Participants did not have enhanced memory for the faces of 'liars' than the faces of individuals telling the truth, again failing to support the prediction that participants would have enhanced memory for 'lying stimuli'. There was also no sex difference recognition memory performance with females failing to remember a greater number of the 'lying stimuli' than males. There was also no relationship between 'lying' ratings of stimuli and recognition memory performance; therefore stimuli that were given a higher 'liar rating' (regardless of whether the stimulus was actually lying or not) were not remembered better. These findings fail to support the literature that has shown enhanced memory for 'cheaters' or 'free-riders' over cooperators.

#### *6.4.3 Autistic traits and detection and memory for 'liars'*

Correlating total AQ score with 'lying' ratings of the stimuli threw up an unexpected result; higher AQ scores in females was significantly positively correlated with success at detecting liars. Therefore, the more autistic traits females possessed the more successful they were at detecting 'liars'. This result is in the opposite direction of outlined prediction that high levels of autistic traits would be associated with impaired ability at detecting 'liars'. However, this result may not be as spurious as it first seems. As outlined by Ekman (1996) above, individuals may be reluctant to put social relationships at risk by confronting potential liars. Therefore, cues to lying may possibly be 'learnt' to be ignored. Those scoring low on the 'social brain' item (i.e. 'social skills' + 'communication') are very likely to be individuals with large social networks and with many personal relationships to maintain, and therefore may have unwittingly adopted this cognitive rule of thumb. Additionally, the result was found only in females. Research of children's playground behaviour shows that females (unlike males) from an early age place a premium on maintaining relationships to the cost of breaking predetermined rules (Lever 1976). It is possible that highly social females have developed a cognitive 'rule of thumb' whereby cues to lying are disregarded in order to maintain harmony within relationships.

Neuropsychological evidence also offers clues to this finding. A study by Setoff, Ekman, Frank, Torreano & Magee (1992) revealed how individuals made more unreceptive to the content of speech, due to damage to the left hemisphere, performed better than normal participants at detecting liars. In a more recent study Etcoff, Ekman, Magee & Frank (2000) found that individuals who were unable to understand words (aphasics) were significantly better than individuals without a language impairment, at detecting lies. Individuals with autism also have impaired language ability. Thus these results are

consistent with our observation that females high in autistic traits out performed more socially adept females in this study.

The significant positive correlation between autistic traits and success at detecting liars in females in this study, coupled with previous research outlined above, suggests performance at detecting liars may not necessarily be facilitated by a very socially adapted brain.

Instead less socially skilled individuals may not register or process all the information that is being emitted from a 'lying stimulus', much of it which may cloud judgement at detecting cues to lying.

#### *6.4.4 Limitations of study*

A possible limitation of this study is that there may not have been enough incentive on behalf of the detector to detect the lie. Failure to detect the lie did not have any real impact on the detectors life, and thus there may not have been sufficient emotional involvement on the part of participants to detect 'liars'. Future research should perhaps attempt to manipulate the incentive to detect liars in order to see if this affects detection performance and recognition memory for liars. However, a recent study has in fact found that participants relatively uninvolved in a judging task had better success at detecting liars than those highly involved (Forrest & Feldman 2000). The authors suggested that the mechanism responsible for this is that those with low task involvement focus on non-verbal cues whereas those with high task involvement rely more on speech cues. Therefore, increasing the incentive for participants to detect liars may not in fact improve their performance.

It is also possible that there was not sufficient information contained in the video clips for participants to successfully detect cues to lying. Future research perhaps could present video clips of individual alibis for a particular imaginary offence, some of which are truthful some of which are false. These alibis could be of approximately one minute duration and thus would contain more cues to lying than the shorter clips used in this study.

#### 6.4.5 *Conclusion*

This study failed to support the hypothesis that participants would be capable of detecting 'lying' stimuli from 'truth-telling' stimuli and also have enhanced memory for the lying stimuli compared to 'truth-telling' stimuli. Females also did not show enhanced detection ability for 'lying' stimuli or enhanced recognition memory for 'lying' stimuli compared to males. This study also found no significant negative correlation between level of autistic traits and success at detecting 'lying' stimuli and recognition memory for 'lying' stimuli. Instead this study found a significant positive correlation between liar detection performance and level of 'Social Brain' autistic traits in females only. This finding is compatible with previous research showing that individuals with damage to the left hemisphere (rendering them more unreceptive to content of speech) have enhanced performance at detection liars. These findings taken together would suggest rather counter intuitively that high levels of social skills may actually impair lie detection. These results of this study taken as a whole highlight the difficulty individuals have at detecting lies and remembering liars as opposed to truth-tellers, and strongly suggest that more extensive research is required to engender a fuller understanding of whether emotional arousal and memory do in fact interact to enhance memory for the faces of liars.

It is suggested that research which incorporates judgements of liars where the 'material to be rated' is of a longer duration (thus containing more 'cues to lying'), emotionally arousing and personally salient, may produce results in the hypothesised direction.

## 7 General Discussion

### 7.1 *Aims and rationale of thesis*

The aim of this thesis was to investigate:

- a) proximate mechanisms involved in memory consolidation for emotional events.
- b) ultimate functions of memory for emotional events.

This thesis presented a diverse range of studies in order to tackle both proximate and ultimate explanations for enhanced memory of emotional events in humans. Proximate mechanisms involved in memory consolidation for emotional material were investigated in Chapters 2 & 3. Ultimate functions of memory and emotion were analysed in chapters 4, 5 & 6. This chapter will first review our findings concerning proximate mechanisms involving memory and emotion (Chapters 2 & 3) before reviewing and discussing ultimate functions of memory and emotion (Chapters, 4, 5 & 6). Finally, the fundamental findings will summarised and implications of this thesis will be discussed.

### 7.2 *Proximate mechanisms involved in memory consolidation for emotional events*

#### 7.2.1 *CPS stress and memory consolidation*

In Chapter 2 three experiments were performed in order to ascertain whether post learning stress hormone activation interacted with the degree of arousal at initial encoding to

enhance memory for emotional material. The effect of sex and sex related traits on memory consolidation for emotional material was also investigated. It was hypothesized that males would show enhanced memory for central details of emotional events, with females hypothesized to show enhanced memory for peripheral details of emotional events. In the first of these experiments, post learning stress hormone activation was not found to enhance memory consolidation of emotional material. There was also no effect of sex or sex related traits on memory consolidation for emotional events. The analysis of heart rate and blood pressure recordings for the course of the experiment indicated that the process of saliva sampling (for cortisol analysis) had inadvertently acted as a psychological stressor with increased heart rate and blood pressure occurring during the saliva sampling phases. This inadvertent stressor may have masked the effects of stress hormone activation on memory consolidation for emotional events.

The second experiment did not involve saliva sampling in order to avoid inducing psychological stress in participants. Instead of depositing saliva, participants were asked to complete two mood questionnaires. This second study again failed to find an effect of stress hormone activation on memory consolidation of emotional material. There was also no effect of sex and sex related traits on memory consolidation of emotional events. After consultation and collaboration with Professor Larry Cahill's laboratory at the Centre of the Neurobiology of Learning and Memory at the University of California, Irvine; a new methodology for a third experiment was developed which was as free as possible from inadvertent stressors. Cahill has previously reported an enhancing effect of post-learning stress hormone activation (employing CPS stress as the stress hormone activator) on memory consolidation of emotional events (Cahill & Alkire 2003; Cahill et al. 2003). In the modified procedure, participants viewed the slide presentation but did not complete any questionnaires, memory tests or deposit any saliva for analysis. In a memory test one week



later, participants completed the free recall and recognition memory tests on the slide presentation and completed the personality and mood questionnaires and the AVLTL. This third experiment again failed to find an effect of post learning stress hormone activation on memory consolidation for emotional material. There was also no effect of sex or sex related traits on memory consolidation for emotional events. The results of these three experiments suggest that the enhancing effect of post-learning stress hormone activation induced by CPS stress is not a robust and replicable phenomenon. The results of these studies suggest that the previously documented effects of males showing enhanced memory for central details of an emotionally arousing event compared to females, and females showing enhanced memory of an emotionally arousing event compared to males, are also not robust and replicable phenomena.

#### *7.2.2 Extrinsic versus intrinsic arousal to the 'to be remembered' stimulus*

“in order for arousal to have any impact on memory, it must be relevant to the to-be-remembered event; merely arousing someone will not suffice” (Libkuman, Nichols-Whitehead, Griffith & Thomas 1999, p. 180).

It is possible that the source of physiological arousal is important in memory consolidation for emotional material. In the three experiments presented in Chapter 2 the physiological arousal was not intrinsically linked to the emotionally arousing stimulus, i.e. the CPS stress bore no relationship to the slide presentation. There is a body of research that indicates it is important that the source of arousal must be semantically linked to the ‘to be remembered’ material. For example, Christianson & Mjörndal (1985) found that administration of adrenaline (the unrelated source of arousal) did not enhance memory for faces. Varner & Ellis (1998) also found that inducing physiological arousal by asking

participants to exercise did not enhance retrieval of 'to be remembered', words.

Libkuman, Nichols-Whitenead, Griffith & Thomas (1999) also found that extrinsic physiological arousal (induced by running energetically on a treadmill) while viewing an emotionally arousing slide presentation also failed to enhance memory consolidation for emotional material. However, Nielson, Yee & Erickson (2005), in a study specifically aimed to test whether the source of arousal needs to be related to the 'to be remembered' material, did find an enhancing effect of arousal on memory for the 'to be remembered material'. These authors asked participants to learn a list of nouns. They then induced arousal in participants by asking them to view an emotionally arousing video, depicting oral surgery. This source of arousal significantly elevated heart rate, and the 'arousal group' had significantly greater memory for the words than the control group who had viewed a neutral video depicting 'tooth-brushing'. Previous studies employing CPS stress (Cahill et al. 2003) and exercise (Nielson & Jensen 1994; Nielson et al. 1996) have also been successful at finding an enhancing effect of arousal on memory using semantically unrelated sources of arousal.

Therefore it would seem that the literature on the importance of trying to link the arousal to the stimulus remains unresolved. It is not clear, therefore, whether the failure to find an enhancing effect of arousal on memory consolidation in this study was due to the source of physiological arousal being semantically unrelated to the 'to be remembered' material.

Further research is needed to elucidate the importance of the semantic relationship between the source of the arousal and the emotional stimulus.

### 7.2.3 *Bodily feedback, SCI and memory for emotional events*

In Chapter 3 the effect of total spinal cord injury transection (SCI) on emotional awareness, emotional expressivity, and memory consolidation of emotional events was investigated. The prevailing mainstream view in Cognitive Neuroscience on the effect of SCI is that it impairs emotional capacities (e.g. emotional arousal, perception, awareness and identification), the extent of which is greater the higher up the spinal cord the lesion occurs. If this view is correct, and emotional arousal is reduced in SCI, then one would also predict that memory for emotional events would also be impaired. Therefore this study is an important contribution to the understanding of how SCI affects emotional capacities and could also shed light on what role autonomic feedback from the body to the brain plays in memory consolidation for emotional events. The results of the study yielded no difference between SCI and control participants in memory consolidation for emotional events. The study also revealed SCI patients did not differ from controls on ‘emotional awareness’ but did report greater levels of ‘strength of emotional expressivity’ and ‘mean emotional expressivity’ *after* SCI compared with before SCI. This finding directly opposes the prevailing view that SCI impairs emotional capacities. The results of this study also have important implications for the proximate mechanisms involved in memory consolidation of emotional material. The prevailing view on the effects of SCI on emotion would predict reduced arousal in response to emotional events and thus reduced memory for those events. However, the results of this study may suggest that other afferent feedback systems, such as feedback via the vagus and other cranial nerves and hormonal feedback via the bloodstream, may play an important role in emotional memory consolidation as well as in emotional expressivity and emotional awareness.

#### *7.2.4 Re-examining what is known about the effects of SCI on emotion*

The results of Chapter 3 force the mainstream view of the effects of SCI on emotion to be questioned and prompt a deeper re-examination of previous research in the field that oppose this mainstream view. It is perhaps wise to begin with Hohmann's seminal study that is responsible for the prevailing view on the effect of SCI on emotion. Recent research has overlooked that Hohmann (1966) found that patients did report an increase in intensities of feelings of sentimentality, i.e. the propensity to cry easily in response to emotional situations. In fact research existed before Hohmann's study suggesting that SCI does not impair emotion; with Dana (1921) failing to find a difference in the intensity of emotional feelings one year after injury in a single SCI patient. Since then, Lowe & Carroll (1985), Jasnos & Hakmiller (1975), Bermond et al. (1987) have all failed to find an impairing effect of SCI on emotion. Additionally, Bermond, et al. (1991), employed a similar design used by Hohmann (1966), when he interviewed 37 SCI patients; asking them to compare the intensities of pre-injury emotional experiences with comparable experiences post injury. Patients also completed self rating scales concerning possible changes in emotional excitability. The authors found that the intensities of the mental responses for fear and anger increased after spinal cord injury and the intensity of somatic responses for fear and anger remained the same. The results from the self-rating scales clearly showed that the majority of patients were convinced that their overall emotional excitability has either remained the same or increased since spinal injury.

Chwalisz, et al. (1988) interviewed spinal injury patients, healthy controls, and wheelchair bound non-spinal injured patients, in order to assess the relationship between the perception of autonomic arousal and the intensity of experienced emotion. The authors found that only spinal injured patients reported stronger fear in their lives presently compared with the past (in the case of spinal injured patients pre-injury). The findings did not support the idea that the perception of autonomic arousal is a vital component of emotion and that emotion cannot occur without it. Similar to the results presented in Chapter 3, the spinal injured patients with the most reduced bodily feelings often reported feeling several emotions more intensely than before their injury. A majority of the spinal injured subjects in the low-feedback group (i.e. those that received the least bodily feedback due to the severity of their injury) reported increases in the intensity of feelings of love, joy, sentimentality, and sadness. Spinal injured patients also reported increases in the intensity of fear than those in other groups. Therefore, it is improbable if perception of autonomic arousal were critical to emotional experience that people would experience many emotions more strongly even after such feedback had been severely reduced.

Further evidence indicating that SCI does not impair emotional capacities comes from research employing the Iowa Gambling Task to test the 'somatic marker' hypothesis, i.e. the idea that bodily (or somatic) feedback to the brain (i.e. a gut instinct) influences decision making by guiding us in a manner adaptive for survival (Damasio 1994; 1999). North & O' Carroll (2001) tested this theory by asking SCI patients, with a lesion at the 6<sup>th</sup> cervical vertebra, to complete the task. The task is a card game requiring the player to try and win as

much money as possible by selecting one card at a time from one of 4 decks. The player slowly learns that 2 decks are 'high risk', incurring large losses, with the other 2 decks a safer option leading to a gradual gain of money. Healthy individuals quickly learn to avoid the 'risky decks', but research has shown that patients with medial frontal lobe damage (Bechara, Damasio, Damasio & Anderson 1994) and bilateral amygdala damage (Bechara, Damasio, Damasio & Lee 1999) fail to display a GSR prior to taking a card from a 'risky' deck, and have impaired performance on this task as a whole. These findings were considered evidence of a lack of a 'somatic marker' or gut instinct leading to impaired decision making. North & O' Carroll (2001) failed to find any difference between the spinal injury group and a sample of matched healthy control subjects, in either card selection strategy or net monetary gain. The authors concluded that in terms of the 'somatic marker' hypothesis, feedback to the brain from the periphery via the vagus and other cranial nerves and hormonal feedback via the blood stream may be equally or more important than afferent feedback via the spinal cord.

Much of the research carried out on the effects of SCI on emotion can be criticised for either using small sample sizes (e.g. Dana 1921) or informal qualitative designs (e.g. Lowe & Carroll 1985; Bermond et al. 1987; Chwalisz et al. 1988; Bermond et al. 1991), which left the results of the studies more susceptible to experimenter bias. Therefore, stricter more quantitative studies were required to investigate the effect of SCI on emotion. O' Carroll et al. (2003) carried out one such study. They hypothesized that considering Alexithymia is a proposed impairment in accessing, experiencing, or describing emotional states (Parker et al. 1999), and assuming that perception of visceral states via afferent feedback may be implicated in the experience of emotion; then patients with total spinal cord transection should score significantly differently from matched control subjects on a measure of Alexythmia.

However, the authors found no difference between the two groups in Alexithymia scores. They concluded that other feedback systems are still functioning in SCI patients, i.e. hormonal feedback via the bloodstream and feedback via cranial nerves and the vagus nerve, and these feedback routes may have an important role to play in perceiving, identifying and experiencing emotion. More recently, Cobos et al. (2002) presented a series of emotionally arousing pictures to 19 spinal injured patients and 19 healthy control participants matched for sex, age and education, while simultaneously recording heart rate. Both groups showed a significantly greater change in heart rate while viewing unpleasant pictures than while viewing pleasant pictures, and subjective measures of arousal showed no difference between both groups. Looking within the spinal injury group; the level, extension and duration of the lesion provided no evidence for a decreased emotional experience.

Therefore the above body of evidence suggests that emotional capacities and emotional intensity is not impaired in individuals with SCI. A recent fMRI study that recorded the cerebral activity of SCI patients as they took part in an aversive fear conditioning task, offers an insight as to the effects of SCI on brain processes in response to an emotional stimulus (Nicotra et al. 2005). The results of the study revealed evidence of a loss of emotional control in SCI patients but no evidence of a loss of emotional intensity. The authors reported an enhancement in activity of the dorsal anterior cingulate, a region activated by emotional processing, in response to threatening stimuli, in SCI patients compared to controls. The authors proposed that with reduced feedback of autonomic responses there may be compensatory activity in the anterior cingulate. These findings suggest that emotional intensity in SCI patients is not in fact dampened, and may in fact offer an explanation for the discovery in this thesis of an increase in emotional expressivity in patients with SCI, after their injury, compared to pre-injury. Future research should also

perhaps consider the possibility that some emotional reactions may be learned in patients with SCI and that this may account for their same (or higher) levels of emotional functioning following injury.

Chapter 3 reports findings contradicting a mainstream view that has been held largely unopposed for forty years. This is the mainstream assumption that the higher the transection is up the spine, the greater the impairment in emotional arousal, perception and identification there will be. This mainstream assumption would also predict impairment in memory consolidation for emotional material. Therefore the current findings force an accepted paradigm to be reassessed and will stimulate renewed research interest in an area that has remained largely unchallenged for years.

#### *7.2.5 The importance of null findings and findings that contradict the mainstream view*

The experimental studies reported in Chapters 2 and 3 are a thorough investigation of the hypotheses. Although these studies produced primarily null findings, from a macro level, these findings make an important contribution to the understanding of the mechanisms involved in memory consolidation of emotional events. Scientific knowledge accumulates via a dynamic process driven by both current and historical developments (Graham & Dayton 2002). The philosopher of science Karl Popper described this process as occurring within a conventional logical framework built upon direct observations that are meticulously tested via independent replication (Popper 1959; 1963). However it now seems clear that this process can be flawed with recent research indicating a publication bias towards statistically significant findings at the expense of non-significant findings of equal or greater merit (Scargle 2000). The more controversial view on the process of scientific research proposed by Thomas Kuhn (1963) describes the accumulation of



scientific knowledge as one where scientists work comfortably within the boundaries of their field (known as ‘normal science’) for long periods, but are punctuated by sharp phases of revolution or ‘extraordinary science’. These intermittent phases occur when accepted paradigms suffer essential tensions and can no longer accommodate new data, forcing scientists to shed the constraints of the paradigms in search of new understanding (Kuhn 1963).

Scargle (2000) reported a publication bias for significant findings at the expense of non-significant findings of equal or greater merit. Additionally, in an examination of 44 peer-reviewed meta-analyses covering a wide range of areas in evolutionary ecological biology, Jennions & Moller (2002) found that, over time, effect sizes of published findings decreased. This effect remained even when the effect of sample size was controlled for. The authors concluded that results suggest a publication bias against weak findings or non-significant results is the most parsimonious explanation. Such an explanation proposes that once a paradigm is established, it becomes harder and harder to change, as non-significant results are seemingly more likely to be ignored by the scientific community. Such a process helps to maintain and extend so called periods of ‘normal science’ according to Kuhn (1963), which ultimately hinders and delays a truer understanding of a biological phenomenon. In order to avoid such pitfalls in the investigation of memory consolidation for emotional material, it is important to give credence to the results presented in this chapter equal to that of significant findings found elsewhere. Only by doing so can an accurate understanding of the processes involved in memory consolidation for emotional events be more quickly reached. These findings force a re-examination of what is known about post learning stress hormone activation’s effect on memory consolidation for emotional material. Ignoring such results may mean a new paradigm is established on false merits and one that may remain unchallenged for many years.

As previously mentioned the mentioned above the work by Jennions & Muller (2000) suggests that once a paradigm is established it becomes harder and harder to change. This seems exactly the case concerning the effects of SCI on emotion. The mainstream view on SCI's effect on emotion was established in the 1960s on the basis of one study (Hohmann 1966). Despite much research disputing this finding since then, the view still prevails, as we see from the latest (6<sup>th</sup>) edition of the psychology undergraduate textbook "An introduction to brain and behaviour" (Kolb & Wishaw 2005), which insists that the decline in emotional intensity is more marked the higher the lesion is on the spine. This view is also championed by the influential neuroscientist Antonio Damasio in his popular science publication "The Feeling of what happens" (1999, p.289), where he also states "the higher the placement of damage in the spinal cord, the more impaired feeling is". This is why the results of Chapter 3 are important as they add to the mass of studies that question the mainstream view. These results make it possible for the 'critical mass' of opposing findings to be reached that finally force a re-examination of a once accepted finding, and as Kuhn (1963) would describe it: provoke a period of 'extraordinary science' (1963).

### *7.3 Ultimate functions of memory for emotional events*

Males and females, and humans in general, have faced a wide range of selection pressures in the evolutionary past; therefore one would expect memory and emotion to have evolved to tackle these differing selective pressures. This thesis aimed to examine just how well memory and emotion are equipped to deal with these adaptive challenges. As discussed in Chapter 1, when a particular trait or behaviour evolves due to its fitness benefit it bestows to an organism, a proximate mechanism must evolve that permits the organism to produce that characteristic (Sober & Wilson 1998). Therefore any adaptive feature of an organism, such as enhanced memory consolidation for emotional events, occurs because there is an internal mechanism inside the organism that produces it. By understanding why we have enhanced memory for emotional material we may elucidate how (proximately) we have enhanced memory for emotional material. The discipline of Evolutionary Psychology argues that framing ultimate causes is an essential requirement for any hypothesizing about proximate causes and that any proximate causal hypothesis is suspect without a firm supporting ultimate explanation (Downes 2005). This thesis aimed to further our understanding of both the proximate mechanisms and ultimate functions of memory for emotional events.

#### *7.3.1 Sex differences in memory and emotion for cues to threat*

As outlined in Chapter 1, males and females have endured differing selective pressures and therefore should have evolved different cognitive adaptations to solve these problems. Chapters 4 & 5 of this thesis investigate the differing selective pressures that have faced males and females in the ancestral past and hypothesise how memory and emotion may

have evolved in an adaptive manner to tackle these selective problems. Chapter 4 considers the argument that attaining and maintaining high social status is particularly important for male reproductive success; and therefore predicts that memory and emotion should interact in an adaptive manner so that males are more emotionally aroused by, and show greater memory for stimuli implying they are of low social status. For females, physical appearance and sexual reputation are more important for reproductive success; therefore females would be predicted to have greater arousal to and enhanced memory for stimuli implying they are physically unattractive and sexually unfaithful. This chapter also looked at how self esteem influenced emotional arousal to, and memory for 'threat' stimuli. Theory and research argues that female self esteem is more reliant on positive self-perception of physical appearance, whereas male self esteem is more closely tied to self perception of their social status. Therefore, it was predicted that self esteem in females would correlate negatively with emotional arousal to and memory for stimuli implying they are physically unattractive. Self-esteem in males, on the other hand, was predicted to negatively correlate with emotional arousal to, and memory for, stimuli implying they are of low social status.

Chapter 4 examined these hypotheses by testing the following predictions:

- a) Males will show greater arousal to, and enhanced memory for, threatening verbal words relating to 'social status'.
- b) Females will show greater arousal to, and enhanced memory for, threatening verbal words relating to 'physical appearance' and 'sexual reputation'
- c) Self esteem is negatively correlated with recall of 'social status' threat words in males, and 'physical appearance' threat words in females.

The first experiment in Chapter 4 employed the emotional Stroop task to measure emotional reaction to the verbal stimuli. The second experiment employed the Dot Probe task to measure emotional reaction to verbal stimuli. Both the emotional Stroop and dot probe tasks failed to detect a differential emotional reaction between males and females to the different ‘threat’ stimuli. However, these null findings may be due to the fact that both these tasks have mixed results in finding effects of emotional arousal to ‘threat’ stimuli in non-clinical samples. The finding that females showed marginally significantly greater recognition memory than males for FN words in Experiment 1, and significantly greater free recall and recognition memory than males for PA words in Experiment 2, strongly suggests that females are more concerned with physical appearance than males. The recognition memory scores of the second experiment showed a significant interaction in memory performance in the hypothesized direction; females showed greater memory for ‘physical appearance’ words, while males showed superior memory for ‘social status’ words. The second experiment also showed a significant negative correlation between recognition memory for ‘physical appearance’ words and self esteem in females. Thus females with low self esteem have better memory for threatening stimuli relating to physical appearance. This result highlights the importance of ‘self perception of physical attractiveness’ for female self esteem and well being.

The experimental studies carried out in Chapter 4 provide evidence that memory and emotion do interact in an adaptive fashion for males and females, with evidence that the sexes remember stimuli that are most important to them from the perspective of reproductive success. The results highlight the effects of sex on memory consolidation of emotional events and also show that self-esteem can amplify the effect of sex; within females those lowest in self esteem showed greater memory for words implying they are physically unattractive.

#### *7.3.1.1 Limitations and implications for future research*

The emotional Stroop and dot probe tasks failed to detect a differential emotional reaction between males and females to the different ‘threat’ stimuli. Although the literature shows both these experimental paradigms are more successful at detecting emotional reactions when testing clinical samples, however, a possible shortcoming of the use of the emotional Stroop and dot probe tests in this study is that each ‘threat’ word is only presented once. Research employing these experimental paradigms typically repeats a set of stimuli, rather than displaying each ‘threat’ word once. The reason ‘threat’ words were only displayed once per participant in this study was to avoid a ‘ceiling effect’ in memory performance for threat words in the subsequent memory tests (i.e. multiple exposure to the threat words may have meant no differences in memory performance would emerge). Future research should also independently evaluate whether the words employed in the study convey what they intend to convey. This could be achieved by asking individuals if the word ‘submissive’, for example, conveys a feeling of low social status to the viewer (in the context of the particular experiment).

The finding that males rate social status ‘threat’ words as likely to be relatively more offensive to other males than to themselves may have implications for future research in the field of individual differences and personality psychology. Participants in this study may either be consciously or subconsciously denying that certain personality characteristics are important to them, while, nevertheless assuming they are important for others. Additionally, the difference in male memory performance between the free recall tests in Experiments 1 & 2 and the recognition memory test in Experiment 2 suggest the importance of perceived anonymity in research of this nature. Online questionnaires, for example, have an ‘anonymous’ feel to them, with the responses ‘disappearing’ from view once the ‘submit’ button is pressed. Participants may have less fear that the experimenter will accidentally see their responses and ‘pass judgement’ on them.

### *7.3.2 Sex differences in memory and emotion for cues to infidelity*

Chapter 5 investigated the selective pressures of relationship infidelity that have faced males and females and how memory and emotion may have evolved to address this adaptive problem. In the ancestral past paternity was always uncertain, therefore it is argued that males evolved a brain module innately predisposing them to jealousy concerning a mate’s sexual infidelity (Buss 1992). Females, on the other hand, risk losing investment in offspring if a mate forms a pair bond with another female. Previous research (Buss 1992) suggests that a sex specific jealousy brain module does not exist, but rather there is a more general mechanism at work. Contextual factors such as relationship status may also be important in determining what types of infidelity cues are more distressing. For example, experience of committed relationships intensifies feelings of jealousy regarding cues to sexual infidelity for females (Harris 2000; 2003b). Therefore one would predict that:

- a) Males will be more emotionally aroused by and have greater memory for cues to a partner's *sexual* infidelity
- b) Females will be more emotionally aroused by, and have greater memory for, cues to a partner's *emotional* infidelity
- c) Females in a committed relationship will show greater emotional arousal to, and enhanced memory for, cues to sexual infidelity than females not in a relationship.

Participants listened to an emotionally arousing narrative containing cues to emotional infidelity and cues to sexual infidelity, and also a 'neutral' narrative matched for word length and amount of information. GSR was recorded for the duration of both narratives to give an index of emotional arousal to the infidelity cues. A thirty minute delay period followed presentation of the stories, after which participants were given a free recall memory test on both stories. The results of the study revealed that females did not have enhanced GSR activity or memory for emotional infidelity cues in comparison to sexual infidelity cues. Likewise, males did not display enhanced GSR activity or memory for sexual infidelity cues in comparison to emotional infidelity cues. Those currently in a committed relationship, however, did elicit greater GSR activity in response to cues to sexual infidelity; however, they did not show enhanced memory for these cues. Also, GSR activity in response to cues to sexual and emotional infidelity did not correlate with memory for those cues.



### *7.3.2.1 Revising the innate module view of jealousy*

Those in a committed relationship showed enhanced GSR responsivity for cues to sexual infidelity compared with those not in a committed relationship. This is the most interesting finding of the study, and together with Harris (2000 & 2003b; who found a similar effect in females) elucidates that experience of being in a relationship intensifies feelings of jealousy regarding cues to sexual infidelity. Relationship status differentially affected memory for the arousing narrative for males and females. Males 'not in relationship' outscored females 'not in a relationship' but this pattern was reversed for males and females 'in a relationship'. Although this interaction was only marginally significant, it suggests that relationship experience differentially affects females compared to males.

The study did not find any support for the innate modular view of sexual jealousy, with no evidence that males and females are innately wired to be upset by different forms of infidelity. Support for the Socio-Cognitive viewpoint was found with females in a relationship displaying greater GSR responsivity to cues to sexual infidelity. The finding highlights the importance of contextual variables and how they might interact with more hardwired sex differences.

To summarize, Chapter 5 presented data showing that regarding relationship jealousy, memory and emotion does not seem to function in a 'hard-wired', sex specific manner, instead contextual factors may be important, such as relationship status and individual differences in what type of infidelity people find more emotionally arousing and thus more memorable.

#### 7.4 *Recognition memory for the faces of 'liars'*

Chapter 6 investigated recognition memory for the faces of 'liars' compared with the faces of individuals 'telling the truth'. During the course of human evolution, humans have lived in social groups (ranging from about 80 to 150 members) (Dunbar 1999). However, in order for group living to be adaptive, our ancestors must have been capable of detecting and remembering acts of deception and the individuals perpetrating those acts, so that appropriate action could be taken against them (Cosmides & Tooby 1992). Research also indicates that individuals that score high on autistic traits have more difficulty at reading emotional information from faces (Baron Cohen 1997). Therefore it may be expected that these individuals may have difficulty at detecting 'liars' from individuals telling the truth. This chapter specifically tested whether;

- a) Individuals showed enhanced ability at detecting 'liars' from 'truth-tellers'.
- b) Individuals showed greater memory for the faces of 'liars' than the faces of 'truth-tellers'.
- c) The level of autistic traits correlated negatively with lie detection and memory performance for 'lying stimuli'.

Participants viewed a series of video clips, half of which contained footage of individuals lying, the other half of which showed individuals telling the truth. Participants rated whether they thought the individual in each clip was lying using a Likert rating scale. Participants received a surprise memory test on the visual stimuli approximately twenty minutes following presentation. Results of the analysis revealed participants did not have enhanced performance at detecting 'liars' from 'non-liars'. Participants also did not show

enhanced memory for the faces of ‘liars’ compared to individuals telling the truth. These findings fail to support the literature that has shown enhanced memory for ‘cheaters’ or ‘free-riders’ over co-operators. Females, but not males, showed a significant positive correlation between level of ‘Social Brain’ autistic traits and success at detecting ‘liars’, opposite to the predicted direction.

Chapter 6 did not show that memory and emotion interacted in an adaptive fashion to enhance memory for the faces of ‘liars’. The failure of participants to detect ‘lying stimuli’ suggests that the stimuli may not have emanated sufficient information to induce an emotional reaction in participants. However, this was designed to be as ecologically valid a test as possible.

#### *7.4.1 Perhaps less is more regarding lie detection?*

Neuropsychological evidence offers clues to the surprising finding produced in this chapter: that female ability at lie detection positively correlates between with level of ‘Social Brain’ autistic traits. Etcoff et al. (1992) revealed how individuals made more unreceptive to the content of speech, due to damage to the left hemisphere, performed better than normal participants at detecting liars. In a more recent study, Etcoff, Ekman, Magee & Frank (2000) found that individuals who were unable to understand words (aphasics) were significantly better than individuals without a language impairment, at detecting lies. Individuals with autism also have impaired language ability. Thus these results are consistent with our observation that females high in autistic traits out performed more socially adept females in this study. Horn, Olson & Karasik (2002) found that individuals fared better at detecting lies when the quality of the video footage was distorted both spatially and temporally. The authors suggest that highly impairing the video quality

may mask cues that are actually non-diagnostic of lying. It is perhaps possible that receiving ‘all’ the visual and verbal information from an individual in the act of lying may allow the ‘liar’ to mask their lie. Reduced perception of information, either via poor image quality as above or via an inability to detect more subtle social information (as in individuals high in certain autistic traits) may actually enhance lie detection ability. It may be that non-verbal body language is the most important information and that ‘liars’ may use speech to mask their lie. Individuals with aphasia or high in ‘social brain’ autistic traits may be more unreceptive to the masking effect of speech and rely instead on non-verbal cues. Congruent with this theory is a finding by Forrest & Feldman (2000) that individuals relatively uninvolved in a judging task had better success at detecting liars than those highly involved. The authors propose that the mechanism responsible for this is that those with low task involvement focus on non-verbal cues whereas those with high task involvement rely more on speech cues.

It is possible that the participants in the study presented in Chapter 6 were not sufficiently motivated to detect ‘liars’. It may be argued that the consequences for not detecting ‘liars’ accurately were not severe enough to sufficiently motivate participants to perform well. Lie detection performance may have been better if the stimuli were more personally salient and emotionally arousing, and also if the consequences for failing to detect liars was greater. However, the research by Forrest & Feldman (2002) suggests that greater motivation to detect lies may in fact lead to greater reliance on verbal rather than nonverbal cues, which in turn leads to impaired lie detection performance. Further research should continue to investigate how motivation to detect liars affects lie detection performance, so a clearer picture of the effects of motivation on lie detection can be determined.

The significant positive correlation between ‘Social Brain’ autistic traits and success at detecting liars in females in this study, coupled with previous research outlined above suggests performance at detecting liars may not necessarily be facilitated by a very socially adapted brain. Instead less socially skilled individuals may not register or process all the information that is being emitted from a ‘lying stimulus’, much of it which may cloud judgement at detecting cues to lying.

### 7.5 *General Conclusion*

The studies reported in this thesis represent an important stepping stone for a more complete and fundamental understanding of the proximate processes and ultimate functions concerning memory consolidation for emotional events. Previous research indicating the post-learning stress hormone activation interacts with the degree of arousal at encoding to enhance memory for emotional material needs to be reassessed in light of the findings of this research. The mainstream view that SCI impairs emotional arousal, perception, and identification due to reduced autonomic feedback from the body to the brain also needs to be re-examined. The finding that this reduced autonomic feedback to the brain, via total spinal cord transection, also does not impair memory consolidation is a novel finding and one that contributes to the growing accumulation of knowledge regarding memory consolidation mechanisms for emotional events. Chapters 4, 5 and 6 looked at ultimate functions of memory for emotional events, and provided some evidence that memory and emotion do interact in a manner congruent with the differing selective pressures that have faced males and females. For example, females showed enhanced memory for threatening words relating to physical appearance. Evidence was also produced suggesting that relationship status may be a better predictor of arousal in

response to cues to sexual infidelity than 'sex'. Although Chapters 2 and 3 yielded some non-significant findings, and findings that contradicted the mainstream view, these findings should serve the important function of stimulating a reassessment and re-examination of the hypotheses they have challenged.

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## **Appendices**

### *Appendix 1*

Narration for Cahill slide presentation narration

Slide 1

“A mother and son are leaving home in the morning”

Slide 2

“She is taking him to visit his father’s workplace”

Slide 3

“The father is a chief laboratory technician in a nearby hospital”

Slide 4

“They check before crossing a busy road”

Slide 5

“While crossing the road, the boy is struck by a runaway car which critically injures him”

Slide 6

“At the hospital the staff prepare the emergency room to which the boy is rushed”

Slide 7

“All morning long surgeons struggle to save the boys life”

Slide 8

“Specialised surgeons were able to successfully reattach the boys severed feet”

Slide 9

“After the surgery while the father stayed with the boy the mother left to phone her other child’s preschool”

Slide 10

“Feeling distraught she phones the pre-school to tell them she will soon pick up her child”

Slide 11

“Heading to pick up her child, she hails a taxi at the no. 9 bus stop”

*Appendix 2.*

*Cahill slide presentation recognition memory test*

**Key:** Correct responses are underlined. Questions in 'bold' are pertaining to central details.

Date: \_\_\_\_\_

Time: \_\_\_\_\_

Participant ID code: \_\_\_\_\_

**Recognition Memory Test**

There will be 5-9 multiple choice questions per slide and I will begin with slide 1 and move progressively on to subsequent slides. I will tell you exactly when the questions refer to the next slide. You will always know to which slide (out of 11) a question refers. Sometimes a question will tell you that you were right or wrong on a previous question. If you find out you were right, great, if you were wrong, just keep going.

Slide 1:1

**Who is pictured in slide 1?**

- (a) a mother and her son
- (b) a father and his son
- (c) a mother and father
- (d) no one is pictured

Slide 1:2

**What are the mother and son doing?**

- (a) eating at a table
- (b) leaving home
- (c) walking
- (d) riding in a car

Slide 1:3

Where are the mother and son standing?

- (a) in front of a school
- (b) in front of their home
- (c) at a bus stop
- (d) next to their car

Slide 1:4

What is the mother doing?

- (a) locking the house door
- (b) tying her son's shoe
- (c) getting into her car
- (d) standing in a doorway

Slide 1:5

What is the colour of the house door?

- (a) green
- (b) black
- (c) red
- (d) blue

Slide 1:6

What is visible in the foreground of the picture?

- (a) lawn
- (b) trees
- (c) steps
- (d) driveway

Slide 1:7

What is the boy carrying?

- (a) a soccer ball
- (b) his lunch
- (c) a backpack
- (d) his teddy bear

Slide 1:8

What time of day is it?

- (a) morning
- (b) afternoon
- (c) evening
- (d) was not mentioned

**Now the second slide**

Slide 2:1

Who is pictured in slide 2?

- (a) mother
- (b) son
- (c) mother and son
- (d) mother and son and one other person in background

**Slide 2:2**

What are they doing?

- (a) standing
- (b) sitting
- (c) walking
- (d) running

**Slide 2:3**

Where are they going?

- (a) to school
- (b) shopping
- (c) father's workplace
- (d) mother's workplace

**Slide 2:4**

What is their position relative to each other?

- (a) walking arm in arm
- (b) walking hand in hand
- (c) he is holding her jacket
- (d) there is no contact between them

**Slide 2:5**

What is their position relative to each other from the viewer's perspective?

- (a) he is on the left
- (b) he is on the right
- (c) he is in front of her
- (d) he is behind her

**Slide 2:6**

You were told that they

- (a) had long planned to do this
- (b) did it on the spur of the moment
- (c) did it after receiving a phone call
- (d) no such information was given

**Slide 2:7**

Their facial expression is

- (a) neutral
- (b) sad
- (c) happy
- (d) excited

**Slide 2:8**

How much of the child can you see?

- (a) full body
- (b) shoulder up
- (c) waist up
- (d) knees up

**Slide 2:9**

Which direction are they walking relative to the viewer?

- (a) towards the viewer
- (b) away from the viewer
- (c) to the left
- (d) to the right

---

**Now the third slide**

Slide 3:1

**Who or what is pictured next?**

- (a) the mother and son
- (b) the father
- (c) all three
- (d) a hospital

Slide 3:2

You were told that the father's occupation is

- (a) a school teacher
- (b) a surgeon
- (c) a laboratory technician
- (d) hospital custodian

Slide 3:3

What is the father doing in this slide?

- (a) working at a lab bench
- (b) looking into a microscope
- (c) sweeping the floor
- (d) posing, looking directly at the camera

Slide 3:4

Relative to the viewer he faces

- (a) left
- (b) right
- (c) directly towards the viewer
- (d) away from the viewer

Slide 3:5

Pictured in the background is

- (a) a microscope
- (b) a door
- (c) a window
- (d) some chemicals

Slide 3:6

The father has

- (a) glasses
- (b) beard
- (c) both
- (d) neither

---

**Now the fourth Slide**

Slide 4:1

Who is pictured in the next slide?

- (a) mother
- (b) mother and son
- (c) father and son
- (d) no one

Slide 4:2

**What are the mother and son doing?**

- (a) getting into a car
- (b) getting into a bus
- (c) waiting at a stop light
- (d) checking before crossing the street

Slide 4.3

Which direction are they looking at from the viewer's perspective?

- (a) both left
- (b) both right
- (c) mother left and son straight ahead
- (d) mother right and son straight ahead

Slide 4.4

What is in the background?

- (a) trees
- (b) a house
- (c) a parked car
- (d) a bicycle

Slide 4:5

The boy stands where relative to the mother from the viewer's perspective?

- (a) on the right
- (b) on the left
- (c) in front of her
- (d) behind her

Slide 4:6

They are standing next to a

- (a) street sign
- (b) parked car
- (c) stop light
- (d) telephone pole



**Now the fifth slide**

Slide 5:1

**What is pictured next?**

- (a) an intersection
- (b) an ambulance
- (c) a car off the road
- (d) a tow truck with a car

Slide 5:2

**What happened in this slide?**

- (a) the boy saw a bad accident happen
- (b) the boy was hit by a run away car
- (c) the boy saw some wrecked cars in a junk yard
- (d) they walked past the scene of a minor accident

Slide 5:3

**You were told that the boy**

- (a) was knocked unconscious
- (b) was critically injured
- (c) was trapped under the car
- (d) was mildly hurt

Slide 5:4

Who was visible in the slide?

- (a) mother
- (b) boy
- (c) some unnamed people
- (d) no one

Slide 5:5

The colour of the car was

- (a) green
- (b) grey
- (c) blue
- (d) brown

Slide 5:6

The car was facing

- (a) towards the viewer to the right
- (b) away from the viewer to the right
- (c) towards the viewer to the left
- (d) away from the viewer to the left

Slide 5:7

In addition to the car you could also see

- (a) an ambulance
- (b) a tow truck
- (c) other cars driving by
- (d) a parked car in the background

Slide 5:8

What was located in the foreground of the picture?

- (a) a bicycle
- (b) a fire hydrant
- (c) some broken glass
- (d) a water-sewer cover

Slide 5:9

The colour of the hydrant was

- (a) white
- (b) yellow
- (c) red
- (d) two-toned

**Now the sixth slide**

Slide 6.1

What is pictured next?

- (a) a tow truck
- (b) an ambulance
- (c) a busy street
- (d) a hospital

Slide 6.2

**You were told that the hospital staff**

- (a) prepared the emergency room for the boy
- (b) are working on victims of a bus crash
- (c) are preparing for a disaster drill
- (d) it was not mentioned

Slide 6.3

What is the colour of the hospital?

- (a) green
- (b) pale blue
- (c) grey
- (d) light brown

Slide 6.4

What is the name of the hospital?

- (a) Bannam County hospital
- (b) County Hospital
- (c) Victory Memorial hospital
- (d) St. Vincent's Hospital

Slide 6.5

What kind of vehicles are pictured in front of the hospital

- (a) cars
- (b) ambulances
- (c) supply trucks
- (d) none are pictured

Slide 6.6

How much of the hospital is visible

- (a) ground floor only
- (b) ground floor and the second floor
- (c) many floors
- (d) many floors and the roof

---

**Now the seventh slide**

Slide 7:1

What is pictured next?

- (a) mother
- (b) surgeons
- (c) father
- (d) nurses

Slide 7:2

Where are the surgeons pictured?

- (a) in an operating room
- (b) scrubbing for surgery
- (c) in a hallway
- (d) by a door

Slide 7:3

**The surgeons were**

- (a) talking with the boy's parents
- (b) practicing drill procedures
- (c) working on the boy
- (d) it was not mentioned

Slide 7:4

What people were visible?

- (a) boy and surgeons
- (b) several surgeons in the background
- (c) several surgeons in the background and one in the foreground
- (d) two surgeons in the foreground

Slide 7.5

The surgeon in the foreground is wearing

- (a) a surgical gown only
- (b) a surgical gown and surgical hat
- (c) glasses and a surgical gown
- (d) all of these

Slide 7.6

What is the expression on his face?

- (a) sad
- (b) happy
- (c) neutral
- (d) shocked

Slide 7.7

You were told that the surgeons worked

- (a) all morning long
- (b) all day long
- (c) all afternoon long
- (d) it was not mentioned

**Now the eighth slide**

Slide 8.1

What is pictured next?

- (a) doctors talking to nurses
- (b) father and mother
- (c) the boy after surgery
- (d) the father and the boy

Slide 8.2

**What had been done to the boy?**

- (a) skin grafts were put on his legs
- (b) his feet were re-attached
- (c) his broken legs were in cast
- (d) it was not mentioned

Slide 8.3

What part of the boy is shown?

- (a) head only
- (b) whole body
- (c) legs only
- (d) torso only

Slide 8:4

Where were scars visible on the body?

- (a) on feet
- (b) near the ankles
- (c) on the knees
- (d) there were no scars visible

Slide 8:5

What else is pictured besides the boy?

- (a) a surgical tool
- (b) an iv drug line
- (c) a pillow
- (d) nothing

Slide 8:6

What is the position of the boy?

- (a) lying on his stomach
- (b) lying on his back
- (c) lying on his side
- (d) sitting

---

**Now the ninth slide**

Slide 9:1

**Who leaves the hospital?**

- (a) the father
- (b) the mother
- (c) the mother and the son
- (d) the mother and the father

Slide 9:2

**Why does the mother leave?**

- (a) to call her parents
- (b) is late for her job
- (c) to call her other child's school
- (d) has an appointment

Slide 9.3

What is she holding in her hand?

- (a) her purse
- (b) her keys
- (c) a soccer ball
- (d) nothing

Slide 9.4

What is she walking near?

- (a) a police station
- (b) a train station
- (c) a library
- (d) a sky scraper

Slide 9:5

What is she walking towards?

- (a) a street light
- (b) a taxi stand
- (c) a street vendor
- (d) a telephone booth

Slide 9:6

Which way is she facing?

- (a) towards viewer
- (b) away from viewer
- (c) walking to the left
- (d) walking to the right

Slide 9.7

The mother's purse is where?

- (a) in her hand
- (b) over her shoulder
- (c) she is not carrying a purse

Slide 9:8

In the middle of the picture is a:

- (a) tall tree
  - (b) stop sign
  - (c) tall pole
  - (d) garbage can
-

**Now the tenth slide**

Slide 10.1

Where is the mother?

- (a) in a police car
- (b) on a curb
- (c) in a telephone booth
- (d) getting into a taxi

Slide 10:2

**Who does the mother call?**

- (a) her parents
- (b) her boss
- (c) her child's school
- (d) the taxi company

Slide 10.3

What is she leaning on?

- (a) a soccer ball
- (b) her purse
- (c) a telephone book
- (d) the door

Slide 10.4

The phone is where, relative to the mother from the viewer's perspective?

- (a) on the right
- (b) on the left
- (c) behind the mother
- (d) is not visible at all

Slide 10:5

**The mother was described as**

- (a) feeling tired
- (b) feeling distraught
- (c) running late
- (d) feeling anxious

---

**Now the eleventh slide**

Slide 11:1

Where is the mother now?

- (a) at a bus stop
- (b) at a taxi stand
- (c) at home
- (d) outside her office building

Slide 11:2

**What is she doing at the bus stop?**

- (a) waiting for a bus
- (b) trying to hail a cab
- (c) crossing the street
- (d) looking for her keys

Slide 11:3

**Where is she going?**

- (a) to speak with her child's teacher
- (b) to pick up her other child
- (c) to her parents house
- (d) it was not clear

Slide 11:4

**What is pictured in the right foreground?**

- (a) a stop sign
- (b) a bench
- (c) a speed limit sign
- (d) an approaching bus

Slide 11:5

**What is the speed limit on the sign?**

- (a) 25 mph
- (b) 35 mph
- (c) 40 mph
- (d) cannot be read

Slide 11:6

**What is the number of the bus stop where she is waiting?**

- (a) No.13
  - (b) No.12
  - (c) No.9
  - (d) No.15
-



The Auditory Verbal Learning Test (AVLT A/B)

Do not re-read List A for recall Trial A6 or A7

	Recall trials						Recall trials		
<b>List A</b>	1	2	3	4	5	<b>List B</b>	B1	A6	A7 <sub>(+20m)</sub>
Drum						Desk			
Curtain						Ranger			
Bell						Bird			
Coffee						Shoe			
School						Stove			
Parent						Mountain			
Moon						Glasses			
Garden						Towel			
Hat						Cloud			
Farmer						Boat			
Nose						Lamb			
Turkey						Gun			
Colour						Pencil			
House						Church			
River						Fish			
# correct									
Total A1 to A5=									
Trial A6-A5=									
Recognition # targets correctly identified =									
# distracters correctly identified =									

**Trial A1,B5 instructions:** “I am going to read a list of words. Listen carefully, for when I stop, you are to repeat back as many words as you can remember. It doesn’t matter in what order you repeat them. Just try to remember as many as you can.”

**Trial A2-5 instructions:** Now I am going to read the same words again, and once again when I stop, I want you to tell me as many words as you can remember, including words you said the first time. It doesn’t matter in what order you say them. Just say as many words as you can remember, whether or not you said them before.”

**Trial A6:** “I now want you to recall as many of the words from list A as you can”

*After 20 minute delay*

**Trial A7:** “I now want you to recall as many of the words from list A as you can.”  
“I would now like to give you a short recognition test involving the words from List A. I will call out a list of words, if you recognize one of those words as belonging to List A please call out ‘yes’, if you think a word does not belong to List A, please call out ‘no’. I will start now.”

<b>Word List for testing RAVLT recognition</b>				
Bell (A)	Home (SA)	Towel (B)	Boat (B)	Glasses (B)
Window (SA)	Fish (B)	Curtain (A)	Hot (PA)	Stocking (SB)
Hat (A)	Moon (A)	Flower (SA)	Parent (A)	Shoe (B)
Barn (SA)	Tree (PA)	Colour (A)	Water (SA)	Teacher (SA)
Ranger (B)	Balloon (PA)	Desk (B)	Farmer (A)	Stove (B)
Nose (A)	Bird (B)	Gun (B)	Rose (SPA)	Nest (SPB)
Weather (SB)	Mountain (B)	Crayon (SA)	Cloud (B)	Children (SA)
School (A)	Coffee (A)	Church (B)	House (A)	Drum (A)
Hand (PA)	Mouse (PA)	Turkey (A)	Stranger (PB)	Toffee (PA)
Pencil (B)	River (A)	Fountain (PB)	Garden (A)	Lamb (B)

“The trial is now over”

*Appendix 4*

Bem sex role inventory (BSRI)

**Please indicate on a 7-point scale how well each of the 60 characteristics listed below describes you.**

		Never or almost never true	Usually not true	Sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true
		<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
1	<b>Self-reliant</b>	1	2	3	4	5	6	7
2	<b>Yielding</b>	1	2	3	4	5	6	7
3	<b>Helpful</b>	1	2	3	4	5	6	7
4	<b>Defends own beliefs</b>	1	2	3	4	5	6	7
5	<b>Cheerful</b>	1	2	3	4	5	6	7
6	<b>Moody</b>	1	2	3	4	5	6	7
7	<b>Independent</b>	1	2	3	4	5	6	7
8	<b>Shy</b>	1	2	3	4	5	6	7
9	<b>Conscientious</b>	1	2	3	4	5	6	7
10	<b>Athletic</b>	1	2	3	4	5	6	7
11	<b>Affectionate</b>	1	2	3	4	5	6	7
12	<b>Theatrical</b>	1	2	3	4	5	6	7
13	<b>Assertive</b>	1	2	3	4	5	6	7
14	<b>Flatterable</b>	1	2	3	4	5	6	7
15	<b>Happy</b>	1	2	3	4	5	6	7
16	<b>Strong personality</b>	1	2	3	4	5	6	7
17	<b>Loyal</b>	1	2	3	4	5	6	7
18	<b>Unpredictable</b>	1	2	3	4	5	6	7
19	<b>Forceful</b>	1	2	3	4	5	6	7

		Never or almost never true	Usually not true	Sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true
20	<b>Feminine</b>	1	2	3	4	5	6	7
21	<b>Reliable</b>	1	2	3	4	5	6	7
22	<b>Analytical</b>	1	2	3	4	5	6	7
23	<b>Sympathetic</b>	1	2	3	4	5	6	7
24	<b>Jealous</b>	1	2	3	4	5	6	7
25	<b>Has leadership abilities</b>	1	2	3	4	5	6	7
26	<b>Sensitive to the needs of others</b>	1	2	3	4	5	6	7
27	<b>Truthful</b>	1	2	3	4	5	6	7
28	<b>Willing to take risks</b>	1	2	3	4	5	6	7
29	<b>Understanding</b>	1	2	3	4	5	6	7
30	<b>Secretive</b>	1	2	3	4	5	6	7
31	<b>Makes decisions easily</b>	1	2	3	4	5	6	7
32	<b>Compassionate</b>	1	2	3	4	5	6	7
33	<b>Sincere</b>	1	2	3	4	5	6	7
34	<b>self-sufficient</b>	1	2	3	4	5	6	7
35	<b>Eager to soothe hurt feelings</b>	1	2	3	4	5	6	7
36	<b>Conceited</b>	1	2	3	4	5	6	7
37	<b>Dominant</b>	1	2	3	4	5	6	7
38	<b>Soft-spoken</b>	1	2	3	4	5	6	7
39	<b>Likable</b>	1	2	3	4	5	6	7
40	<b>Masculine</b>	1	2	3	4	5	6	7
41	<b>Warm</b>	1	2	3	4	5	6	7
42	<b>Solemn</b>	1	2	3	4	5	6	7

		Never or almost never true	Usually not true	Sometimes but infrequently true	Occasionally true	Often true	Usually true	Always or almost always true
43	<b>Willing to take a stand</b>	1	2	3	4	5	6	7
44	<b>Tender</b>	1	2	3	4	5	6	7
45	<b>Friendly</b>	1	2	3	4	5	6	7
46	<b>Aggressive</b>	1	2	3	4	5	6	7
47	<b>Gullible</b>	1	2	3	4	5	6	7
48	<b>Inefficient</b>	1	2	3	4	5	6	7
49	<b>Acts as a leader</b>	1	2	3	4	5	6	7
50	<b>Childlike</b>	1	2	3	4	5	6	7
51	<b>Adaptable</b>	1	2	3	4	5	6	7
52	<b>Individualistic</b>	1	2	3	4	5	6	7
53	<b>Does not use harsh language</b>	1	2	3	4	5	6	7
54	<b>Unsystematic</b>	1	2	3	4	5	6	7
55	<b>Competitive</b>	1	2	3	4	5	6	7
56	<b>Loves children</b>	1	2	3	4	5	6	7
57	<b>Tactful</b>	1	2	3	4	5	6	7
58	<b>Ambitious</b>	1	2	3	4	5	6	7
59	<b>Gentle</b>	1	2	3	4	5	6	7
60	<b>Reliable</b>	1	2	3	4	5	6	7

## Appendix 5

### Big 5

#### Please read the following instructions carefully

On the following pages, there are phrases describing people's behaviours. Please use the response options below to describe how accurately each statement describes you. Describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses will be kept in absolute confidence. Please read each statement carefully, and then circle the number that corresponds with how accurately the statement describes you.

#### Response Options

1: Very Inaccurate    2: Moderately Inaccurate    3: Neither Inaccurate nor Accurate  
4: Moderately Accurate    5: Very Accurate

1. Am the life of the party.	1	2	3	4	5
2. Feel little concern for others.	1	2	3	4	5
3. Am always prepared.	1	2	3	4	5
4. Get stressed out easily.	1	2	3	4	5
5. Have a rich vocabulary.	1	2	3	4	5
6. Don't talk a lot.	1	2	3	4	5
7. Am interested in people.	1	2	3	4	5
8. Leave my belongings around.	1	2	3	4	5
9. Am relaxed most of the time.	1	2	3	4	5
10. Have difficulty understanding abstract ideas	1	2	3	4	5
11. Feel comfortable around people.	1	2	3	4	5
12. Insult people.	1	2	3	4	5
13. Pay attention to details.	1	2	3	4	5
14. Worry about things.	1	2	3	4	5
15. Have a vivid imagination.	1	2	3	4	5
16. Keep in the background.	1	2	3	4	5
17. Sympathise with other's feelings.	1	2	3	4	5
18. Make a mess of things.	1	2	3	4	5
19. Seldom feel sad.	1	2	3	4	5
20. Am not interested in abstract ideas.	1	2	3	4	5
21. Start conversations.	1	2	3	4	5
22. Am not interested in other people's problems	1	2	3	4	5
23. Get chores done right away.	1	2	3	4	5
24. Am easily disturbed.	1	2	3	4	5
25. Have excellent ideas.	1	2	3	4	5
26. Have little to say.	1	2	3	4	5
27. Have a soft heart.	1	2	3	4	5

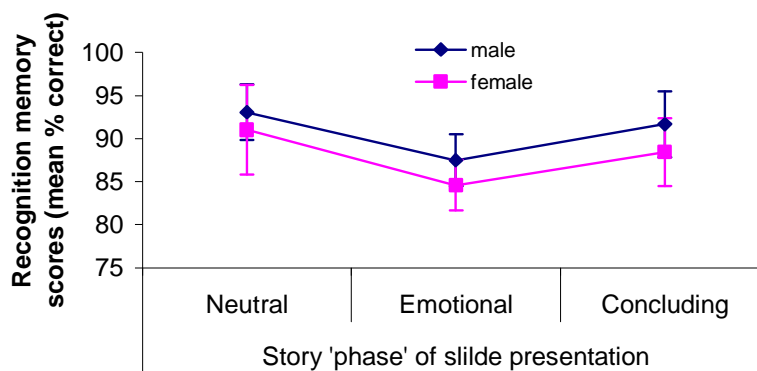
28. Often forget to put things back in their proper place	1	2	3	4	5
29. Get upset easily.	1	2	3	4	5
30. Do not have a good imagination.	1	2	3	4	5
31. Talk to a lot of different people at parties	1	2	3	4	5
32. Am not really interested in others.	1	2	3	4	5
33. Like order.	1	2	3	4	5
34. Change my mood a lot.	1	2	3	4	5
35. Am quick to understand things.	1	2	3	4	5
36. Don't like to draw attention to myself.	1	2	3	4	5
37. Take time out for others.	1	2	3	4	5
38. Shirk my duties.	1	2	3	4	5
39. Have frequent mood swings.	1	2	3	4	5
40. Use difficult words.	1	2	3	4	5
41. Don't mind being the centre of attention	1	2	3	4	5
42. Feel others' emotions.	1	2	3	4	5
43. Follow a schedule.	1	2	3	4	5
44. Get irritated easily.	1	2	3	4	5
45. Spend time reflecting on things.	1	2	3	4	5
46. Am quiet around strangers.	1	2	3	4	5
47. Make people feel at ease.	1	2	3	4	5
48. Am exacting in my work.	1	2	3	4	5
49. Often feel sad.	1	2	3	4	5
50. Am full of ideas.	1	2	3	4	5

## Chapter 2 Experiment 1

### *Recognition memory for central details and the effects of CPS*

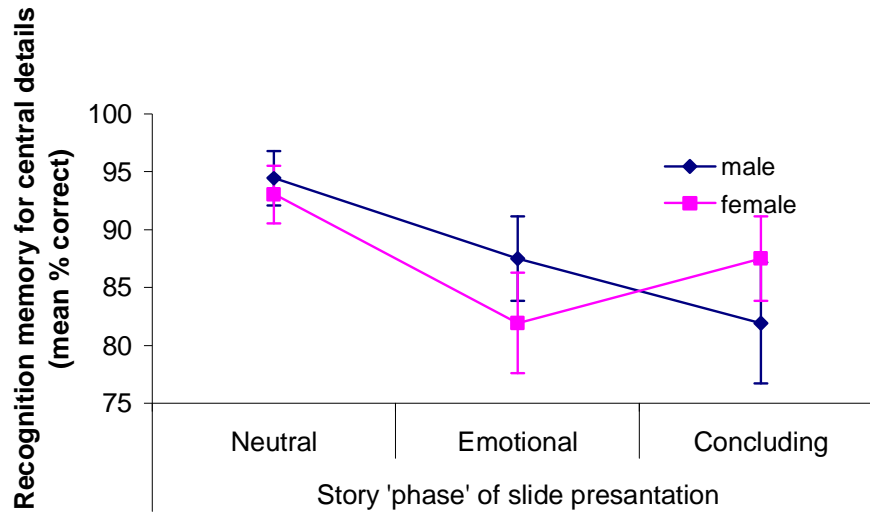
There was no 'slide phase' \* 'sex' interaction in memory scores for central details [F(2,90)=.616, p=.542]. There was no 'slide phase' \* 'stress condition' interaction on memory scores for central details [F(2,90)=1.057, p=.352]. There was also no 'slide phase' \* 'sex' \* 'experimental condition' interaction on recognition memory scores for central details. There was no main effect of 'sex' on memory scores for central details [F(1,45)=.392, p=.534]. There was also no main effect of 'stress condition' on memory scores [F(1,45)=.428, p=.516]. There was also no 'sex' \* 'stress condition' interaction on memory scores for central details [F(1,45)=.534, p=.516].

**Figure 8.1** Recognition memory scores for central details: males versus females. Error bars represent +1/-1 standard error of the mean.





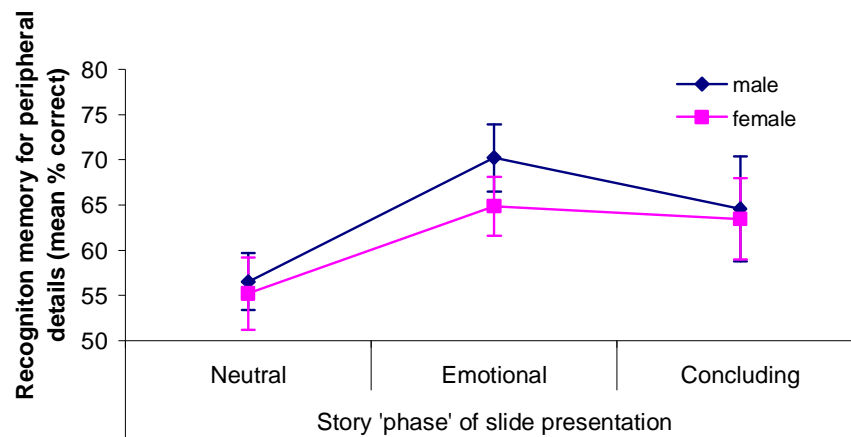
**Figure 8.2** Effects of CPS on recognition memory for central details: males versus females. Error bars represent +1/-1 standard error of the mean.



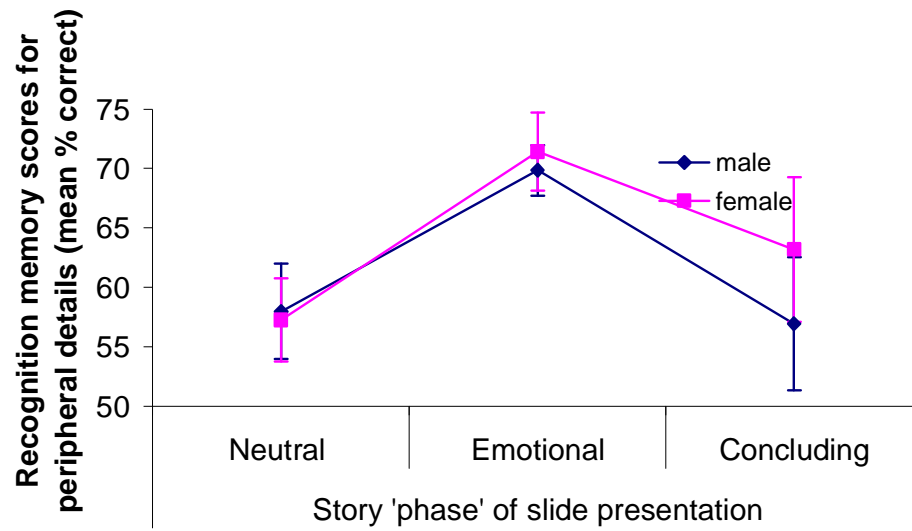
*Recognition memory performance for peripheral details and the effects of CPS*

There was no 'slide phase' \* 'sex' interaction on memory scores for peripheral details [F(1,727, 77.715)=.46, p=.605]. There was no 'slide phase' \* 'stress condition' interaction on free recall memory scores [F(2,90)=1.148, p=.322]. There was also no 'side phase' \* 'sex' \* 'stress condition' interaction on memory scores for peripheral details [F(1,727, 77.715)=.295, p=.745]. There was no main effect of 'sex' on peripheral memory scores [p=.968]. There was no main effect of 'stress condition' on peripheral memory scores [F(1, 45)=.009, p=.924]. There was also no 'sex' \* 'experimental condition' interaction on memory scores for peripheral details [F(1,45)=.633, p=.43]

**Figure 8.3** Recognition memory for peripheral details: males versus females. Error bars represent +1/-1 standard error of the mean.



**Figure 8.4** Effect of CPS on recognition memory for peripheral details: males versus females. Error bars represent +1/-1 standard error of the mean.



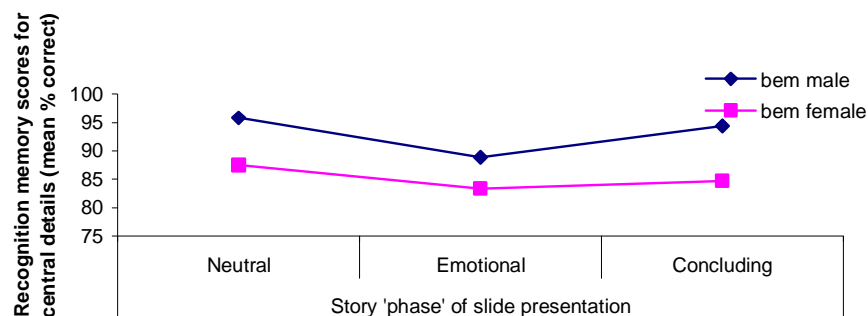
*Sex related traits, memory performance for central and peripheral details, and the effects of CPS.*

### Central details

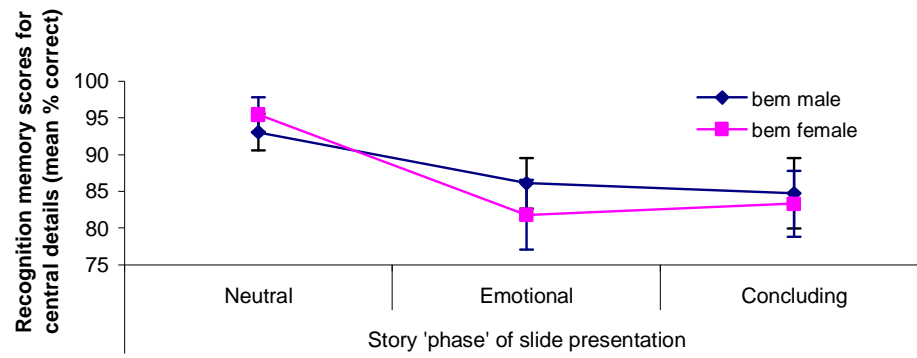
There was no 'slide phase' \* 'experimental condition' interaction on memory scores for central details [ $F(2,86)=1.332, p=.269$ ]. There was also no 'slide phase' \* 'stress condition' \* 'Bem sex' interaction on memory scores for central details [ $F(2,86)=.145, p=.865$ ]. There was no main effect of 'stress condition' on memory scores for central details [ $F(1,43)=.47, P=.497$ ]. There was no main effect of 'Bem sex' on memory scores for central details [ $F(1,43)=3.248, p=.079$ ]. There was no 'stress condition' \* 'Bem sex' interaction on memory scores for central details [ $F(1,43)=1.855, p=.18$ ]. No difference in 'total' recognition memory for central details was found between 'Bem males' and 'Bem females' in the CPS group [ $F(1,21)=.111, p=.742$ ]

**Figure 8.5** Recognition memory for central details 'Bem males' versus 'Bem females'.

Error bars represent  $+1/-1$  standard error of the mean.



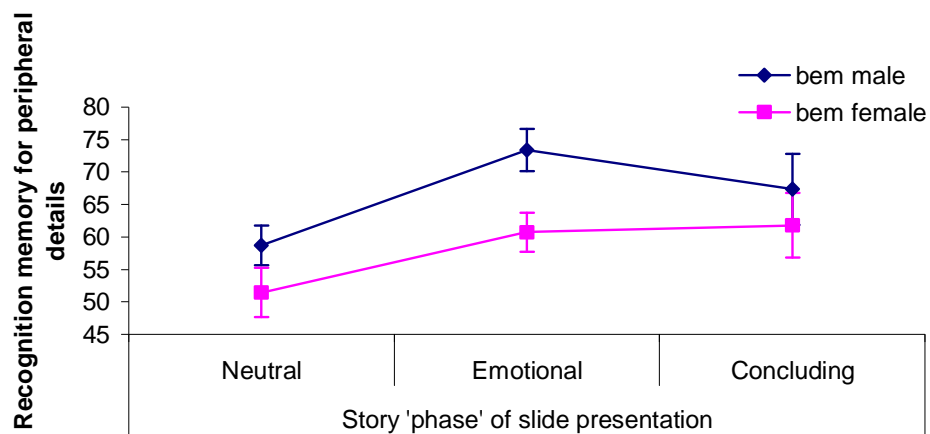
**Figure 8.6** Effects of CPS on recognition memory for central details ‘Bem males’ versus ‘Bem females’. Error bars represent +1/-1 standard error of the mean.



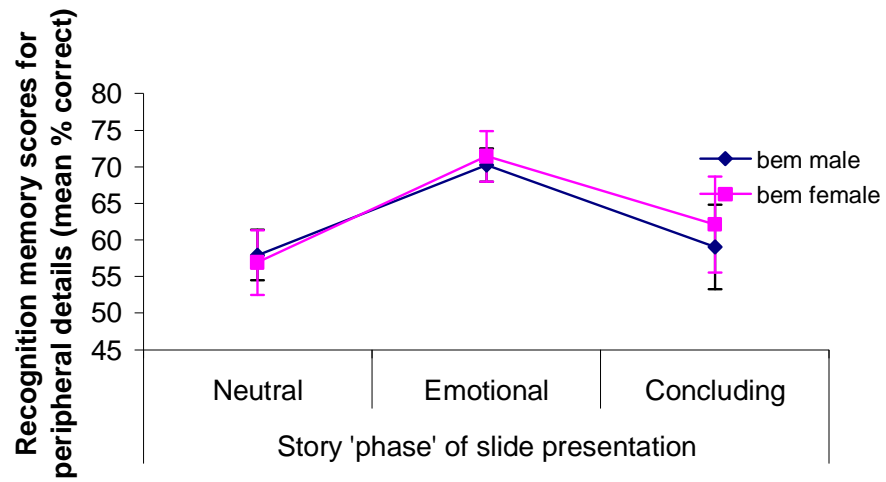
### Peripheral details

There was no 'slide phase' \* 'stress condition' interaction on memory for peripheral details [F(2,86)=1.356, p=.263]. There was no 'slide phase' \* 'Bem sex' interaction on memory scores for central details [F(2,86)=.415, p=.662]. There was also no 'slide phase' \* 'experimental condition' \* 'Bem sex' interaction on memory for peripheral details [F(2,86)=.305, p=.738]. There was no main effect of 'stress condition' on memory scores for peripheral details [F(1,43)=.051, p=.823]. There was no main effect of 'Bem sex' on memory scores for peripheral details [F(1,43)=1.385, p=.246]. There was also no 'stress condition' \* 'Bem sex' interaction on memory scores for peripheral details [F(1,43)=2.305, p=.136]. See Figures 8.7 and 8.8.

**Figure 8.7** Recognition memory for peripheral details: 'Bem males' versus 'Bem females'. Error bars represent +1/-1 standard error of the mean.



**Figure 8.8** Effects of CPS on recognition memory for peripheral details: 'Bem males' versus 'Bem females'. Error bars represent +1/-1 standard error of the mean.



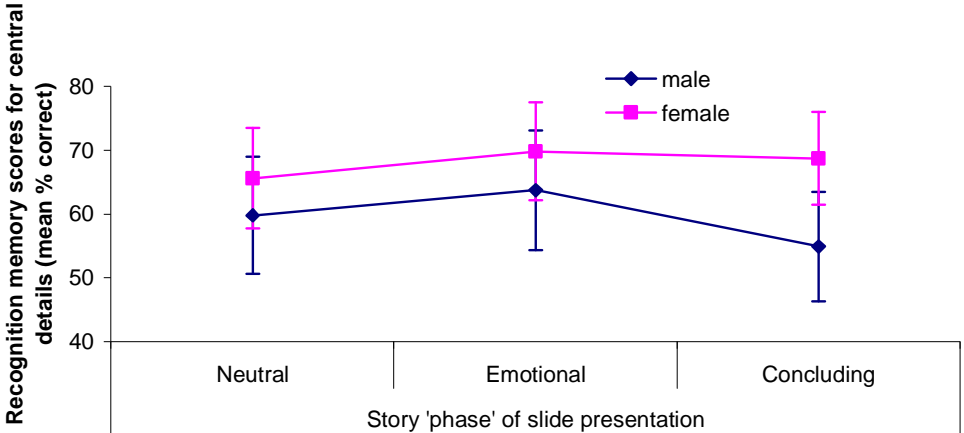
## **Chapter 2 Experiment 2**

### *Recognition memory performance for central details and the effect of CPS*

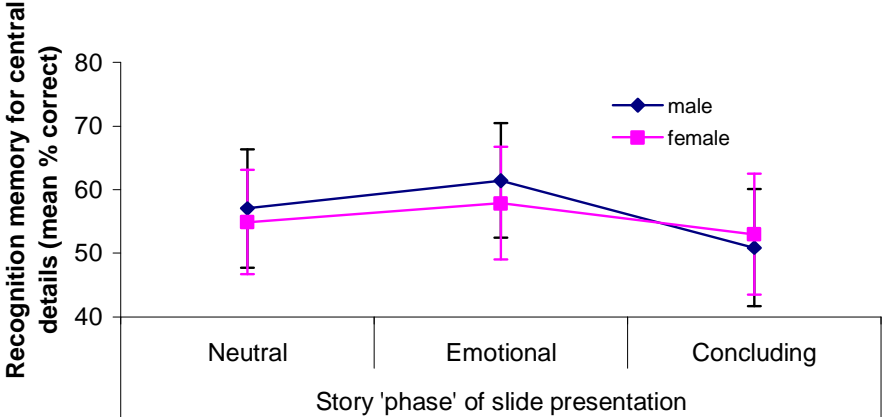
A 2-way repeated measure ANOVA revealed there was no 'slide phase' \* 'sex' interaction on memory scores for central details [ $F(2,130)=1.139$ ,  $p=.323$ ]. There was no 'slide phase' \* 'stress condition' interaction on memory scores for central details [ $F(2,130)=.247$ ,  $p=.782$ ]. There was also no 'slide phase' \* 'stress condition' \* 'sex' interaction on recognition memory scores for central details. The analysis also revealed no main effect of 'stress condition' on memory scores [ $F(1,65)=.911$ ,  $p=.343$ ], and no main effect of 'sex' on memory scores [ $F(1,65)=.197$ ,  $p=.659$ ]. There was also no 'stress condition' \* 'sex' interaction on memory scores for central details [ $F(1,65)=.346$ ,  $p=.558$ ] (see Figures 9.1 & 9.2)



**Figure 9.1** Recognition memory for central details: males versus females. Error bars represent +1/-1 standard error of the mean.



**Figure 9.2** Effects of CPS on recognition memory for central details: males versus females. Error bars represent +1/-1 standard error of the mean.



### *Recognition memory performance for peripheral details and the effects of CPS*

A 2 way repeated measures ANOVA revealed there was no 'slide phase' \* 'sex' interaction on memory scores for peripheral details [ $F(2,130)=.305$ ,  $p=.737$ ]. There was no 'slide phase' \* 'stress condition' interaction on memory scores for peripheral details [ $F(2,130)=.148$ ,  $p=.862$ ]. There was also no 'slide phase' \* 'sex'\* 'stress condition' interaction on memory scores for peripheral details. The analysis also revealed that there was no main effect of 'sex' on memory scores for peripheral details [ $F(1,65)=.349$ ,  $p=.557$ ]. There was also no main effect of 'stress condition' on memory scores for peripheral details [ $F(1,65)=.776$ ,  $p=.382$ ]. There was also no 'sex' \* 'stress condition' interaction on memory scores for peripheral details [ $F(1,65)=.0001$ ,  $p=.994$ ] (see Figures 9.3 & 9.4)

**Figure 9.3**

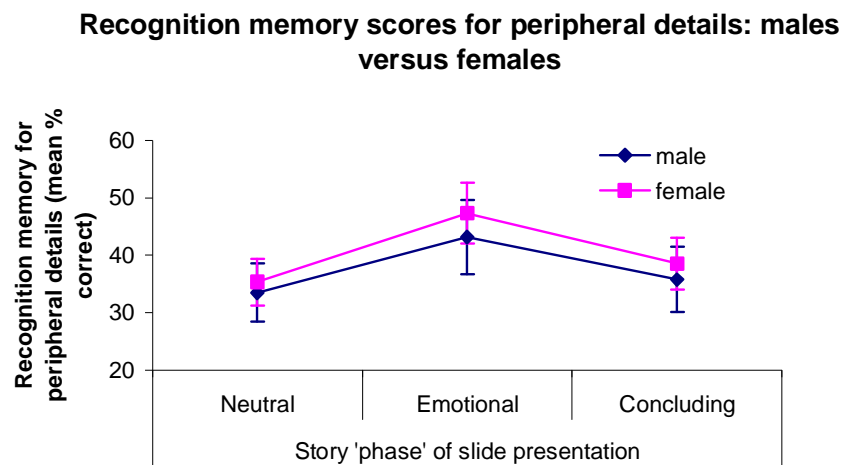
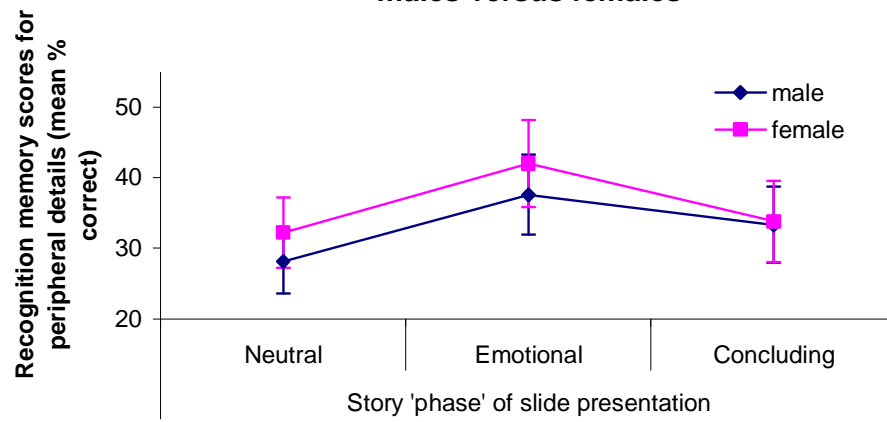


Figure 9.4

Effects of CPS on recognition memory for peripheral details:  
males versus females



*Sex related traits, memory performance for central and peripheral details, and the effects of CPS stress*

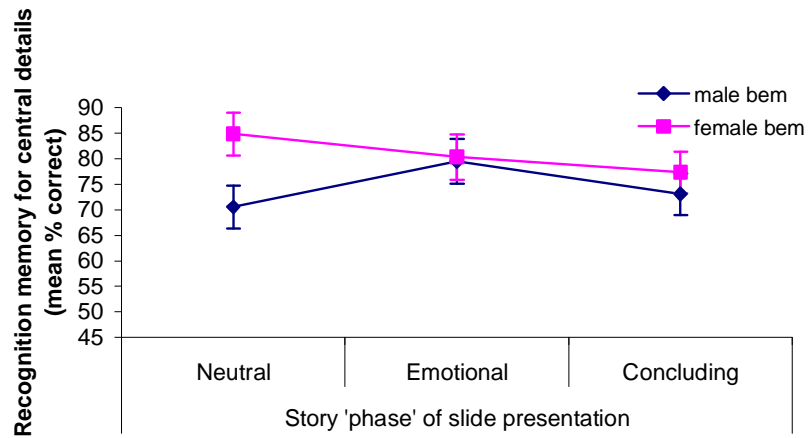
Reliability: Cronbachs Alpha was used to determine the internal reliability of both the masculine and feminine dimensions of the BSRI. For Bem masculinity  $\alpha = .84$ , for Bem femininity  $\alpha = .77$ .

Central details

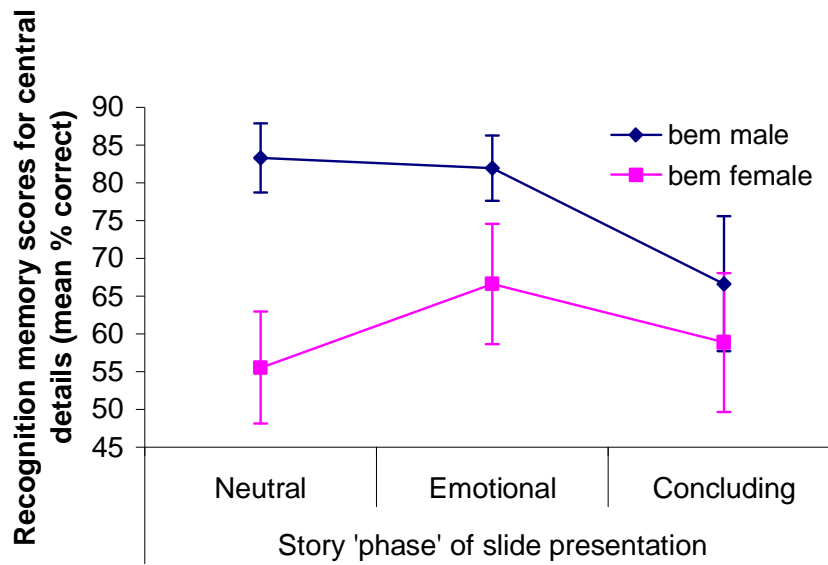
A 2 way repeated measures ANOVA revealed there was no 'slide phase' \* 'stress condition' interaction on memory scores [F(2,130)=.593, p=.555] for central details. There was also no 'slide phase' \* 'Bem sex' interaction on memory performance. There was a 'side phase' \* 'stress condition' \* 'Bem sex' interaction on memory performance for central details [F(2,130)=3.361, p=.039]. Further analysis revealed this was due to CPS group 'Bem males' having significantly greater memory for the Neutral phase than CPS group 'Bem females' [F(1,25)=9.02, p=.006]. There was no significant main effect of 'stress condition' on memory scores for central details [F(1,65)=2.567, p=.116]. There was no main effect of 'Bem sex' on memory performance [F(1,65)=.925, p=.341]. There was a significant interaction of 'stress condition' \* 'Bem sex' on memory performance [F(1,65)=4.596, p=.037]. A one way ANOVA revealed this interaction was due to control group 'Bem females' having significantly great total memory performance for central details than CPS group 'Bem females' [F(1,24)=5.44, p=.028]. (see Figures 9.5 & 9.6 )

**Figure 9.5** Recognition memory for central details: 'Bem males' versus 'Bem females'.

Error bars represent  $\pm 1$  standard error of the mean.



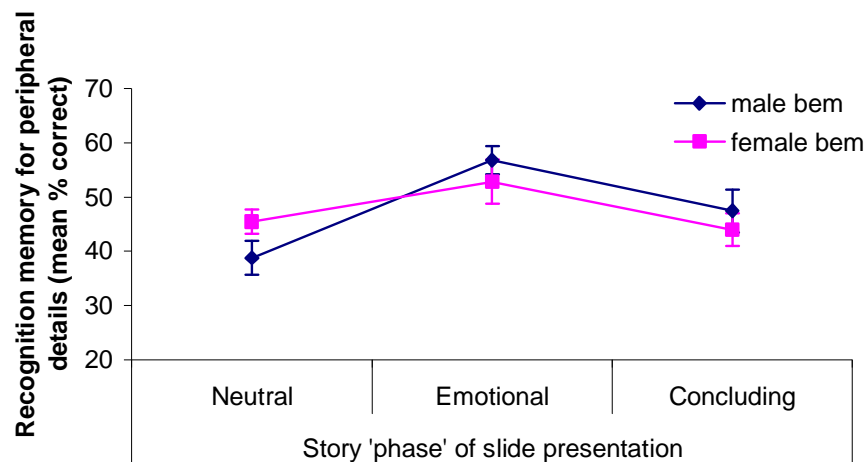
**Figure 9.6** Effects of CPS on recognition memory for central details: 'Bem males' versus 'Bem females'. Error bars represent +1/-1 standard error of the mean.



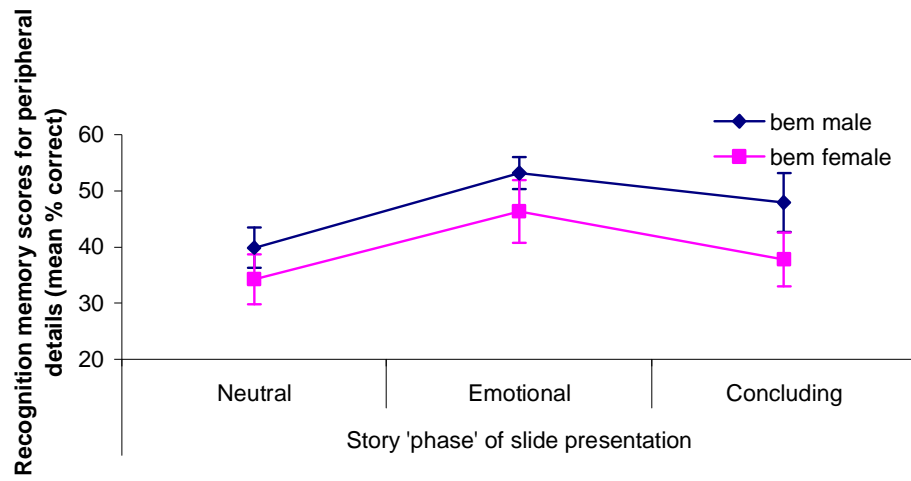
### Peripheral details

A 2 way repeated measures ANOVA revealed there was no 'slide phase' \* 'stress condition' interaction on memory scores for peripheral details [ $F(2, 130) = 1.173, p = .814$ ]. There was no 'slide phase' \* 'Bem sex' interaction on memory scores [ $F(2, 130) = 1.58, p = .211$ ]. There was also no 'slide phase' \* 'stress condition' \* 'Bem sex' interaction on memory scores for peripheral details [ $F(1.7, 82.1) = .593, p = .555$ ]. The analysis also revealed no main effect of 'stress condition' on memory scores for peripheral details. There was also no main effect of 'Bem sex' on memory scores for peripheral details [ $F(1, 47) = 1.428, p = .238$ ]. There was no also no 'stress condition' \* 'Bem sex' interaction on memory scores for peripheral details [ $F(1, 47) = 1.240, p = .271$ ]. (see Figures 9.7 & 9.8)

**Figure 9.7** Recognition memory for peripheral details: 'Bem males' versus 'Bem females'. Error bars represent +1/-1 standard error of the mean.



**Figure 9.8** Effects of CPS on recognition memory for peripheral details: 'Bem males' versus 'Bem females'. Error bars represent +1/-1 standard error of the mean.





Appendix 8

Spielberger State anxiety questionnaire

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the number that corresponds to the appropriate response 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 you 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 am regretful	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 rested	1	2	3	4
9	I feel anxious	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 "high strung"	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 over excited and "rattled"	1	2	3	4
19	I feel joyful	1	2	3	4
20	I feel pleasant	1	2	3	4

Appendix 9

Spielberger Trait anxiety questionnaire

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the number that corresponds to the appropriate response 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.

		<b>Almost never</b>	<b>sometimes</b>	<b>often</b>	<b>Almost always</b>
1	I feel pleasant	1	2	3	4
2	I tire quickly	1	2	3	4
3	I feel like crying	1	2	3	4
4	I wish I could be as happy as others seem to be	1	2	3	4
5	I am losing out on things because I can't seem to make up my mind soon enough	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 cannot 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 am inclined to take things hard	1	2	3	4
12	I lack self confidence	1	2	3	4
13	I feel secure	1	2	3	4
14	I try to avoid facing a crisis or difficulty	1	2	3	4
15	I feel blue	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

Appendix 10

The Berkeley Emotional Expressivity Questionnaire

Instructions

I am now going to read you a list of statements regarding how you feel emotionally. For each statement I read out, please indicate your agreement or disagreement. Please answer each statement according to how you are now, not how you were or how you see yourself in the future. Do so by calling out the appropriate number on the scale (1= strongly disagree, 4= neutral, 7= strongly agree) that most accurately describes each statement for you, you can also use the numbers in between.

		STRONGLY DISAGREE			NEUTRAL			STRONGLY AGREE
		1	2	3	4	5	6	7
1	Whenever I feel positive emotions, people can easily see exactly what I am feeling.							
2	I sometimes cry during sad movies.							
3	People often do not know what I am feeling.							
4	I laugh out loud when someone tells me a joke that I think is funny.							
5	It is difficult for me to hide my fear.							
6	When I am happy my feelings show.							
7	My body reacts very strongly to emotional situations.							
8	I've learned it is better to suppress my anger than to show it.							
9	No matter how nervous or upset I am, I tend to keep a calm exterior.							
10	I am an emotionally expressive person.							
11	I have strong emotions.							
12	I am sometimes unable to hide my feelings, even though I would like to.							
13	Whenever I feel negative emotions, people can easily see exactly what I am feeling.							
14	There have been times I have not been able to stop crying even though I tried to stop.							

<b>15</b>	I experience my emotions very strongly.							
<b>16</b>	What I am feeling is written all over my face.							

**Part II specifically for patients with SCI**

I am now going to read you the same list of statements regarding emotional expressivity that I read to you earlier. For each statement I read, please indicate your agreement or disagreement. Please answer each statement according to how you think you would have been prior to your spinal injury. Do so by calling out the appropriate number on the scale (1= strongly disagree, 4= neutral, 7= strongly agree) that most accurately describes each statement for you.

		STRONGLY DISAGREE			NEUTRAL			STRONGLY AGREE
		1	2	3	4	5	6	7
<b>1</b>	Whenever I feel positive emotions, people can easily see exactly what I am feeling.							
<b>2</b>	I sometimes cry during sad movies.							
<b>3</b>	People often do not know what I am feeling.							
<b>4</b>	I laugh out loud when someone tells me a joke that I think is funny.							
<b>5</b>	It is difficult for me to hide my fear.							
<b>6</b>	When I am happy my feelings show.							
<b>7</b>	My body reacts very strongly to emotional situations.							
<b>8</b>	I've learned it is better to suppress my anger than to show it.							
<b>9</b>	No matter how nervous or upset I am, I tend to keep a calm exterior.							
<b>10</b>	I am an emotionally expressive person.							
<b>11</b>	I have strong emotions.							
<b>12</b>	I am sometimes unable to hide my feelings, even though I would like to.							

<b>13</b>	Whenever I feel negative emotions, people can easily see exactly what I am feeling.							
<b>14</b>	There have been times I have not been able to stop crying even though I tried to stop.							
<b>15</b>	I experience my emotions very strongly.							
<b>16</b>	What I am feeling is written all over my face.							

**The Levels of Emotional Awareness Scale**

Participant ID \_\_\_\_\_

**INSTRUCTIONS**

Please describe what you would feel in the following situations. The only requirement is that you use the word “feel” in your answers. You may make your answers as brief or as long as necessary to express how you would feel. In each situation there is another person mentioned. Please indicate how you think that other person would feel as well.

1. You are traveling in a foreign country. A person from that country who you know makes derogatory remarks about your native country. How would you feel? How would the other person feel?
2. As you drive over a suspension bridge you see a person standing on the other side of the guardrail, looking down at the water. How would you feel? How would the person feel?
3. Your partner has been gone for several weeks but finally comes home. As your partner opens the door....how would you feel? How would your partner feel?
4. Your boss tells you that your work has been unacceptable and needs to be improved. How would you feel? How would your boss feel?
5. You are waiting in line at the bank. The person in front of you steps up to the window and begins a very complicated transaction. How would you feel? How would the person in front of you feel?
6. You and your partner are driving home from an evening out with friends. As you turn onto your street you see fire-engines parked near your home. How would you feel? How would your partner feel?
7. You have been working hard on a project for several months. Several days after submitting it, your boss stops by to tell you that your work was excellent. How would you feel? How would your boss feel?
8. You receive an unexpected long-distance phone call from a doctor informing you that your mother has died. How would you feel? How would the doctor feel?
9. You tell a friend who is feeling lonely that she/he can call you whenever she/he needs to talk. One night she/he calls at 4:00 a.m. How would you feel? How would your friend feel?
10. Your dentist has told you that you have several cavities and schedules you for a return visit. How would you feel? How would the dentist feel?
11. Someone who has been critical of you in the past pays you a compliment. How would you feel? How would the other person feel?

12. Your doctor told you to avoid fatty foods. A new colleague at work calls to say that she/he is going out for pizza and invites you to go along. How would you feel? How would your colleague feel?
13. You and a friend agree to invest money together to begin a new business venture. Several days later you call the friend back only to learn that she/he changed her/his mind. How would you feel? How would your friend feel?
14. You fall in love with someone who is both attractive and intelligent. Although this person is not well off financially, this doesn't matter to you -- your income is adequate. When you begin to discuss marriage, you learn that she/he is actually from an extremely wealthy family. She/he did not want that known for fear that people would only be interested in her/him for her/his money. How would you feel? How would she/he feel?
15. You and your best friend are in the same line of work. There is a prize given annually to the best performance of the year. The two of you work hard to win the prize. One night the winner is announced: your friend. How would you feel? How would your friend feel?

Appendix 12

The Hospital anxiety and depression scale (HADS)

I am now going to ask you a series of questions that are designed to help identify how you feel. I will read each item and give you 4 possible responses. Please tell me the reply which comes closest to how you have been feeling in the past few weeks. Don't take too long over your replies: your immediate reaction to each item will probably be more accurate than a long thought out response.

- |  |  |
|--|--|
| <p><b>1 I feel tense or "wound up"</b></p> <p>Most of the time _____</p> <p>A lot of the time _____</p> <p>Time to time, occasionally _____</p> <p>Not at all _____</p>  | <p><b>2 I feel as if I am slowed down</b></p> <p>Nearly all the time _____</p> <p>Very often _____</p> <p>Sometimes _____</p> <p>Not at all _____</p>  |
| <p><b>3 I still enjoy the things I used to do</b></p> <p>Definitely as much _____</p> <p>Not quite so much _____</p> <p>Only a little _____</p> <p>Hardly at all _____</p>   | <p><b>4 I get a sort of frightened feeling like butterflies in the stomach</b></p> <p>Not at all _____</p> <p>Occasionally _____</p> <p>Quite often _____</p> <p>Very often _____</p>                                    |
| <p><b>5 I get a sort of frightened feeling as if something awful is about to happen</b></p> <p>Very definitely and quite badly _____</p> <p>Yes, but not too badly _____</p> <p>A little but it doesn't worry me _____</p> <p>Not at all _____</p> | <p><b>6 I have lost interest in my appearance</b></p> <p>Definitely _____</p> <p>I don't take so much as I should _____</p> <p>I may not take quite as much care _____</p> <p>I take just as much care as ever _____</p> |
| <p><b>7 I can laugh and see the funny side of things</b></p> <p>As much as I always could _____</p> <p>Not quite so much now _____</p> <p>Definitely not so much now _____</p> <p>Not at all _____</p>   | <p><b>8 I feel restless as if I have to be on the move</b></p> <p>Very much indeed _____</p> <p>Quite a lot _____</p> <p>Not very much _____</p> <p>Not at all _____</p>   |
| <p><b>9 Worrying thoughts go through my mind</b></p> <p>A great deal of the time _____</p> <p>A lot of the time _____</p> <p>From time to time but not too often _____</p> <p>Not at all _____</p>   | <p><b>10 I look forward with enjoyment to things</b></p> <p>As much as I ever did _____</p> <p>Rather less than I used to _____</p> <p>Definitely less than I used to _____</p> <p>Hardly at all _____</p>               |
| <p><b>11 I feel cheerful</b></p> <p>Not at all _____</p> <p>Not often _____</p> <p>Sometimes _____</p> <p>Most of the time _____</p>   | <p><b>12 I get sudden feelings of panic</b></p> <p>Very often indeed _____</p> <p>Quite often _____</p> <p>Not very often _____</p> <p>Not at all _____</p>  |



13 **I can sit at ease and feel**

**relaxed**

Definitely

Usually

Not often

Not at all

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

14 **I can enjoy a good book or radio or TV**

**programme**

Often

Sometimes

Not often

Very seldom

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Words employed in the emotional Stroop task in Chapter 4, Experiment 1

Offensive words	Control words		Positive words	
Female Negative	Fat (2221)	Undivided (118)	Unclear(948)	Intelligent(1895)
	Flabby (157)	Fast (2183)	Adaptive(315)	Sincere(481)
	Unfaithful(132)	Bumpy (157)	Strategic(3039)	Honest(2960)
	Ugly(1365)	Tactile (138)	Numerous(3216)	Generous(2307)
Male Negative	Promiscuous (118)	Plain (1358)	Damp(1571)	Modest(2301)
	Weak (3571)	Unsure(627)	Visual(3328)	Determined(948)
	Submissive (142)	Limited(5146)	Sleek(325)	Assertive(314)
	Subordinate (406)	Vivid(1029)	Symmetric(353)	Dominant(3048)
	Pathetic (635)	Coded(145)	Uneven(689)	Confident(3242)
General Negative	Cowardly (146)	Chilled(109)	Responsive(630)	Brave(1571)
	Stupid (3207)	Sharp(3553)	Legislative(1879)	Gorgeous(627)
	Sly (327)	Finishing(142)	Binary(486)	Shapely(144)
	Dishonest (359)	Experienced(409)	Middle(2943)	Attractive(5152)
	Selfish (693)	Medium(630)	Logical(2315)	Chaste(108)
	Arrogant (642)	Valid(2286)	Swift(772)	Faithful(950)

Frequency values are in parentheses

Appendix 14

Words employed in the dot probe task in Chapter 4, Experiment 2

Offensive words		Control words				
Physical Appearance	Fat (2221)	Unsure (627)	Cosy (630)	Steady (2032)	Undivided (118)	Lean (681)
	Ugly (1365)	Limited (5146)	Muddy (633)	Assorted (176)	Tactile (138)	Latent (655)
	Chubby (131)	Vivid (1029)	Poetic (691)	Shivery (54)	Twinkling (71)	Spacious (652)
	Flabby (157)	Coded (145)	Civilian (767)	Co-educational (36)	Acrylic (143)	Periodic (564)
	Unattractive (337)	Chilled (109)	Municipal (835)	Newish (35)	Square (1412)	Mobile (568)
Sexual Reputation	Promiscuous (118)	Unclear (948)	Ambiguous (837)	Diskless (35)	Sharp (3553)	Governmental (631)
	Unfaithful (132)	Adaptive (315)	Indoor (895)	All-new (33)	Finishing (824)	Dual (1139)
	two-timing (10)	Strategic (3039)	Trading (977)	Inexact (33)	Experienced (409)	Inner (4471)
	Adulterous (39)	Numerous (3216)	Static (1089)	Diffused (34)	Medium (630)	Rational (2321)
	Lusty (67)	Damp (1571)	Concrete (1141)	Waxy (34)	Retiring (146)	Apposite (80)
Social Status	Weak (3571)	Legislative (1879)	Elected (1259)	Off-beat (54)	Visual (3328)	Uncertain (2007)
	Submissive (142)	Binary (486)	Novel (1291)	Overblown (54)	Sleek (325)	Narrow (127)
	Subordinate (406)	Middle (2943)	Irrelevant (1364)	Scanning (58)	Symmetric (353)	Lucid (213)
	Pathetic (635)	Logical (2315)	Double (1436)	Reducible (61)	Uneven (689)	Implicit (1161)
	Cowardly (146)	Valid (2286)	Profound (1434)	Stringy (61)	Responsive (630)	Freezing (74)
General Negative	Stupid (3207)	Royal (1867)	Payable (1666)	Included (211)	Fast (2183)	Vague (1505)
	Sly (327)	Industrial (1571)	Precious (1768)	Budding (218)	Plain (1358)	Malleable (102)
	Dishonest (359)	Complete (2534)	Official (4720)	Managing (257)	Coral (133)	Planned (2277)
	Selfish (693)	High (3243)	Changing (3252)	Vested (786)	Bumpy (157)	Frequent (2348)
	Arrogant (642)	Full (3348)	Swift (772)	Revised (769)	Oceanic (337)	Wet (2889)

Frequency values are in parentheses

**Rosenberg Self-Esteem Scale**

Instructions: Below is a list of statements dealing with your general feelings about yourself. If you strongly agree, circle **SA**. If you agree with the statement, circle **A**. If you disagree, circle **D**. If you strongly disagree, circle **SD**.

1.	On the whole, I am satisfied with myself.	SA	A	D	SD
2.	At times, I think I am no good at all.	SA	A	D	SD
3.	I feel that I have a number of good qualities.	SA	A	D	SD
4.	I am able to do things as well as most other people.	SA	A	D	SD
5.	I feel I do not have much to be proud of.	SA	A	D	SD
6.	I certainly feel useless at times.	SA	A	D	SD
7.	I feel that I'm a person of worth, at least on an equal plane with others.	SA	A	D	SD
8.	I wish I could have more respect for myself.	SA	A	D	SD
9.	All in all, I am inclined to feel that I am a failure.	SA	A	D	SD
10.	I take a positive attitude toward myself.	SA	A	D	SD

*Appendix 16*

Modified version of Socio-sexuality inventory (SOI)

1. Sex without love is OK.

*Strongly disagree 1 2 3 4 5 6 7 8 9 strongly agree*

2. I can imagine myself being comfortable and enjoying sex with casual partners.

*Strongly disagree 1 2 3 4 5 6 7 8 9 strongly agree*

3. I would have to be closely attached to someone (emotionally and psychologically) before I could feel comfortable and fully enjoy having sex with him or her.

*Strongly disagree 1 2 3 4 5 6 7 8 9 strongly agree*

Appendix 17

The Autism spectrum quotient (AQ) questionnaire

**The AQ**

**TO BE COMPLETED**

**ALL INFORMATION REMAINS STRICTLY CONFIDENTIAL**

Name:..... Sex:.....

Date of birth:..... Today's Date.....

**How to fill out the questionnaire**

*Below are a list of statements. Please read each statement very carefully and rate how strongly you agree or disagree with it by circling your answer.*

**DO NOT MISS ANY STATEMENT OUT.**

Please return the completed questionnaires in the freepost envelope provided.

*Examples*

E1. I am willing to take risks.	definitely agree	slightly agree	slightly disagree	Definitely disagree
E2. I like playing board games.	definitely agree	slightly agree	slightly disagree	Definitely disagree
E3. I find learning to play musical instruments easy.	definitely agree	slightly agree	slightly disagree	Definitely Disagree
E4. I am fascinated by other cultures.	definitely agree	slightly agree	slightly disagree	Definitely disagree

1	I prefer to do things with others rather than on my own.	definitely agree	slightly agree	Slightly disagree	definitely disagree
2	I prefer to do things the same way over and over again.	definitely agree	slightly agree	Slightly disagree	definitely disagree
3	If I try to imagine something, I find it very easy to create a picture in my mind.	definitely agree	slightly agree	Slightly disagree	definitely disagree
4	I frequently get so strongly absorbed in one thing that I lose sight of other things.	definitely agree	slightly agree	Slightly disagree	definitely disagree
5	I often notice small sounds when others do not.	definitely agree	slightly agree	Slightly disagree	definitely disagree
6	I usually notice car number plates or similar strings of information.	definitely agree	slightly agree	Slightly disagree	definitely disagree
7	Other people frequently tell me that what I've said is impolite, even though I think it is polite.	definitely agree	slightly agree	Slightly disagree	definitely disagree
8	When I'm reading a story, I can easily imagine what the characters might look like.	definitely agree	slightly agree	Slightly disagree	definitely disagree
9	I am fascinated by dates.	definitely agree	slightly agree	Slightly disagree	definitely disagree
10	In a social group, I can easily keep track of several different people's conversations.	definitely agree	slightly agree	Slightly disagree	definitely disagree
11	I find social situations easy.	definitely agree	slightly agree	Slightly disagree	definitely disagree
12	I tend to notice details that others do not.	definitely agree	slightly agree	Slightly disagree	definitely disagree
13	I would rather go to a library than a party.	definitely agree	slightly agree	Slightly disagree	definitely disagree
14	I find making up stories easy.	definitely agree	slightly agree	Slightly disagree	definitely disagree
15	I find myself drawn more strongly to people than to things.	definitely agree	slightly agree	Slightly disagree	definitely disagree
16	I tend to have very strong interests which I	definitely	slightly	Slightly	definitely

	get upset about if I can't pursue.	agree	agree	disagree	disagree
17	I enjoy social chit-chat.	definitely agree	slightly agree	Slightly disagree	definitely disagree
18	When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree	slightly agree	Slightly disagree	definitely disagree
19	I am fascinated by numbers.	definitely agree	slightly agree	Slightly disagree	definitely disagree
20	When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree	slightly agree	Slightly disagree	definitely disagree
21	I don't particularly enjoy reading fiction.	definitely agree	slightly agree	Slightly disagree	definitely disagree
22	I find it hard to make new friends.	definitely agree	slightly agree	Slightly disagree	definitely disagree
23	I notice patterns in things all the time.	definitely agree	slightly agree	Slightly disagree	definitely disagree
24	I would rather go to the theatre than a museum.	definitely agree	slightly agree	Slightly disagree	definitely disagree
25	It does not upset me if my daily routine is disturbed.	definitely agree	slightly agree	Slightly disagree	definitely disagree
26	I frequently find that I don't know how to keep a conversation going.	definitely agree	slightly agree	Slightly disagree	definitely disagree
27	I find it easy to "read between the lines" when someone is talking to me.	definitely agree	slightly agree	Slightly disagree	definitely disagree
28	I usually concentrate more on the whole picture, rather than the small details.	definitely agree	slightly agree	Slightly disagree	definitely disagree
29	I am not very good at remembering phone numbers.	definitely agree	slightly agree	Slightly disagree	definitely disagree
30	I don't usually notice small changes in a situation, or a person's appearance.	definitely agree	slightly agree	Slightly disagree	definitely disagree
31	I know how to tell if someone listening to me is getting bored.	definitely agree	slightly agree	Slightly disagree	definitely disagree



32	I find it easy to do more than one thing at once.	definitely agree	slightly agree	Slightly disagree	definitely disagree
33	When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree	slightly agree	slightly disagree	definitely disagree
34	I enjoy doing things spontaneously.	definitely agree	slightly agree	slightly disagree	definitely disagree
35	I am often the last to understand the point of a joke.	definitely agree	slightly agree	slightly disagree	definitely disagree
36	I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree	slightly agree	slightly disagree	definitely disagree
37	If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree	slightly agree	slightly disagree	definitely disagree
38	I am good at social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
39	People often tell me that I keep going on and on about the same thing.	definitely agree	slightly agree	slightly disagree	definitely disagree
40	When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41	I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42	I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43	I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44	I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45	I find it difficult to work out people's intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
46	New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47	I enjoy meeting new people.	definitely	slightly	slightly	definitely

	agree	agree	disagree	disagree
48 I am a good diplomat.	definitely agree	slightly agree	slightly disagree	definitely disagree
49 I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree
50 I find it very easy to play games with children that involve pretending.	definitely agree	slightly agree	slightly disagree	definitely Disagree