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**UNIVERSITY OF SOUTHAMPTON**

FACULTY OF MEDICINE, HEALTH AND LIFE SCIENCES

School of Psychology

The Time Course and Specificity of Attentional Bias in  
Individuals with Chronic Headache

by

**Daniel E. Schoth**

Thesis for the degree of Doctor of Philosophy

December 2010

UNIVERSITY OF SOUTHAMPTON

ABSTRACT

FACULTY OF MEDICINE, HEALTH AND LIFE SCIENCES

SCHOOL OF PSYCHOLOGY

Doctor of Philosophy

THE TIME COURSE AND SPECIFICITY OF ATTENTIONAL BIAS IN  
INDIVIDUALS WITH CHRONIC HEADACHE

By Daniel Eric Scoth

The relationship between pain and attentional processes has been extensively researched, and is one of the most thoroughly studied areas within the pain literature. In recent years, increased research has investigated whether individuals with chronic pain demonstrate attentional bias towards pain-related information, although inconsistent evidence has been reported. Relatively little investigation into the time-course of bias exists however, along with an incomplete understanding of the importance of bias specificity. The aim of this doctoral thesis was to provide important information pertaining to these issues, via an investigation of attentional bias in individuals with chronic headache. The results of five empirical studies are presented in this thesis. Study 1 reported a meta-analysis of former research utilising the visual-probe task in this area, showing individuals with chronic pain to demonstrate significantly greater bias towards pain-related information compared to pain-free controls. Experiments 1 – 3 each presented a visual-probe task to individuals with chronic headache and healthy controls, showing bias in chronic headache to be specific towards headache-related information. The investigation of time-course suggests biases to be present in both initial orienting and maintained attentional stages, although are more prominent during the latter. Experiment 4 utilised an emotional Stroop task, although found no evidence of bias towards more general representations of pain. Overall, the results presented in this doctoral thesis provide evidence for disorder-specific bias in chronic headache, adding considerable knowledge to the field of pain and attentional processes.

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## DECLARATION OF AUTHORSHIP

I, Daniel Eric Schoth, declare that the thesis entitled ‘The Time Course and Specificity of Attentional Bias in Individuals with Chronic Headache’ and the work presented in this thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- parts of this work have been published as: Schoth, D. E. & Liossi, C. (2010). Attentional bias towards pictorial representations of pain in individuals with chronic headache. *The Clinical Journal of Pain*. 26 (3): 244 – 250.

**Signed:** .....

**Date:**.....

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*I can do everything through him who gives me strength. Philippians 4:13*

## **Thesis Introduction and Overview**

Chronic pain disorders are highly prevalent (Breivik, Collett, Ventafridda, Cohen & Gallacher, 2006), and are considered a major health concern (Gatchel, Peng, Peters, Fuchs, & Turk, 2007). In addition to physical pain and discomfort, such medical conditions are associated with a range of negative experiences, including increased risk of psychological co-morbidities such as anxiety and depression (Tüzün, 2007), financial loss (Rizzo, Abbott & Berger, 1998), and isolation (Rose, 1994). Cognitive deficits have also been commonly found in chronic pain patients (Hart, Martelli & Zasler, 2000), supporting the notion that chronic pain leads to chronic attentional interruption (Eccleston & Crombez, 1999). Chronic headache, the focus of this doctoral research, is a relatively common form of chronic pain, with an estimated global prevalence of 3% (Strover et al., 2007). Serious implications upon quality of life have been associated with chronic headache, which affects every area of daily life (Davis & Grassley, 2005). Chronic headache disorders can result in serious disability for both the individual and their families (Jensen & Stovner, 2008), making treatment a priority. In many instances, however, evidence of underlying structural disease is not apparent from medical investigation (Pascual, Colás & Castillo, 2001), and standard pharmacological interventions may be ineffective alone (Lipchik & Nash, 2002). An understanding of the factors associated with the onset and maintenance of chronic headache is therefore highly important, including psychological factors in general, and factors related to processes of attention in particular. Indeed, the relationship between attention and pain remains one of the most thoroughly studied areas within the pain literature (Brown & Jones, 2008). However, more specific focus into chronic headache disorders and attention is needed, which is provided in this doctorate thesis.

Over the past decade, increased research has investigated whether individuals living with chronic pain display attentional biases towards information related to their pain conditions. Theories of emotional processing, including Wells and Matthews' (1994; 1996) Self-Regulatory Executive Function Model (S-REF) and Bower's network model (1981), predict information-processing biases towards information congruent with an individual's emotional concerns. Supporting such theories, there is evidence to suggest that individuals with chronic pain display both interpretation and memory biases towards pain-related information (Pincus & Morley, 2001). Accordingly, bias in attentional processing should also be present. A

number of theoretical models of pain and attention also raise this prediction, including the Schema Enmeshment Model of Pain (Pincus & Morley, 2001), the Misdirected Problem-Solving Model (Eccleston & Crombez, 2007), numerous fear-avoidance models (e.g. Vlaeyen & Linton, 2000), and the motivational account of attention to pain (Van Damme, Legrain, Vogt, and Crombez, 2010). Despite such predictions, evidence for attentional bias in chronic pain has remained mixed from research utilising well established cognitive paradigms such as the visual-probe and the emotional Stroop tasks. However, numerous methodological limitations may be raised in this former research, including recruitment of heterogeneous samples of chronic pain patients, and the use of stimuli not exclusively relevant to the sensory or affective dimensions of pain, or adequately rated in key characteristics known to affect attentional processing such as valence and arousal. Considering the visual-probe task, in many instances the methodology adopted has not encouraged an equal processing of both displayed stimuli, or has included additional fixation points between such stimuli and the probes to be responded to. In both instances, the ability of the visual-probe task to reliably detect bias is limited. Furthermore, it is apparent that in chronic pain, very little research has addressed the time-course or specificity of attentional bias, although both have important clinical and theoretical implications. Based upon these limitations, further investigation was deemed necessary, forming the basis for this doctoral thesis.

The main aim of the current programme of research was to determine whether individuals with chronic pain demonstrate attentional bias towards pain-related information, with a specific focus upon chronic headache. Considering theoretical models of attention and pain, it was predicted that such biases would be found relative to healthy, pain-free individuals. Based upon this prediction, this thesis also sought to address a series of further questions that have yet to be fully investigated. Firstly, the time-course of attentional bias has not been sufficiently explored in chronic pain. Utilising the visual-probe task, this thesis aimed to clarify the attentional stages during which individuals with chronic pain demonstrate biased attention, specifically investigating the stages of initial orienting and maintenance of attention (Allport, 1989). Secondly, questions remain regarding the specificity of bias in chronic pain, including whether biases are disorder-specific, or are shown towards more general pain-related information and/or non-pain related threat. This thesis aimed to address this by investigating bias in a specific chronic pain disorder, chronic headache, across a range of pain and non-pain related stimuli. Thirdly,

evidence for underlying correlates of attentional bias in chronic pain has remained inconsistent, although further investigation into a range of individual difference variables is needed (Asmundson, Wright, & Hadjistavropoulos, 2005). A final aim was to therefore provide detailed information on correlates of bias, including individual differences variables not adequately addressed in former research.

Throughout this programme of research, a number of innovations were made to enhance methodological quality, and increase the chances of detecting bias in those with chronic headache, should they exist. Firstly, the majority of former investigations have made use of linguistic, single word stimuli. Compared to pictures, single words may be considered relatively weak as emotional stimuli (Bradley, Mogg, & Miller, 2000). Additionally, the use of words adds a further confounding variable, as subjective frequency of use is likely to differ between patients and controls (Bradley, Mogg, Falla, & Hamilton, 1998). Pictorial stimuli were therefore adopted in this research, which are likely to possess higher levels of ecological validity (Kindt & Brosschot, 1997), and not have been formerly encountered by participants. Importantly, such stimuli were carefully selected and prepared, rated on dimensions of valence, arousal, and emotional content, and matched on qualities of luminance, colour, and orientation. Secondly, the decision was made to explore a homogenous chronic pain group (i.e. chronic headache), which would allow for the development of stimuli specifically relevant to this particular group (i.e. headache-related stimuli), and also allow for an investigation of bias specificity. Thirdly, this doctoral thesis adopted two presentation times in the visual-probe task, corresponding to initial orienting (500ms) and maintained attention (1250ms). To date, very little research has investigated biases at these two stages of attentional processing in adult chronic pain samples. Finally, this research also investigated underlying correlates of attentional bias, exploring a number of variables not typically addressed in former investigations, including rumination, pain acceptance, pain coping strategies and perceptions of headache-related disability.

Overall, this doctoral thesis clarifies a number of important questions concerning patterns of attentional bias in chronic pain. Chapter 1 provides a detailed discussion of the nature of pain and its impact upon the individual and society, with specific focus upon chronic headache. Chapter 2 critically evaluates the relationship between attentional processes and pain perception, including a review of relevant theoretical models of attention and pain. In order to meet the adopted aims specified above, five empirical investigations were conducted over the course of the doctoral

thesis. Chapter 3 (Study 1) provides an important starting point, presenting a systematic review and meta-analysis of former research to utilise the visual-probe task to investigate attentional bias in chronic pain. Inconsistent results have been found with this paradigm, although to date no meta-analysis has been published. This meta-analysis tested the hypothesis that, compared to healthy controls, individuals with chronic pain would demonstrate significantly greater bias towards pain-related information displayed at presentation times associated with initial orienting of attention. Chapter 4 presents the first experiment in this thesis to use the visual-probe task, investigating the time-course of attentional bias in individuals with chronic headache, towards pictorial, headache-related stimuli. It was hypothesised that individuals with chronic headache would demonstrate significantly greater bias towards such stimuli compared to healthy controls. In order to investigate potential underlying correlates of bias, a number of questionnaire measures were administered to participants. A secondary hypothesis was that present pain intensity, monitoring processing style, catastrophising, state and trait anxiety, and anxiety sensitivity would positively correlate with attentional bias, while pain self-efficacy and ignoring of pain would negatively correlate with attentional bias.

Chapter 5 presents the second visual-probe experiment, which attempted to expand upon the results of the first experiment, clarifying the specificity of attentional bias. In this second study, bias towards interpersonal threat (i.e. angry and sad) and positive (i.e. happy) facial expressions was explored in chronic headache and healthy control groups. It was hypothesised that no significant differences would be found between these two groups in regards to attentional patterns. Further exploring the importance of stimuli specificity in chronic headache, Chapter 6 (Experiment 3) examined whether biases in chronic headache are shown towards disorder-relevant stimuli only (i.e. headache images), or also towards more general representations of pain (i.e. facial expressions of pain). Bias towards objects representing illness and poor health (i.e. health-threat images) was also investigated, along with bias towards non-pain related, general threat. The chronic headache group was predicted to demonstrate significant bias towards headache images. Underlying correlates of bias were further explored, and it was hypothesised that in chronic headache participants, fear of pain would significantly correlate with bias towards health-threat images, rumination with bias towards headache images, and pain vigilance with bias towards pain images.

Chapter 7 presents the fourth experiment, which utilised the emotional Stroop task to investigate biases towards pain, angry, sad, fear, and happy facial expressions. Chronic headache participants were hypothesised to show significantly greater Stroop interference on pain images compared to healthy controls. Additionally, executive control was examined in both participant groups. Bias towards facial expressions of pain was predicted to correlate with impaired executive control in the chronic headache group. Significantly poorer performance on measures of executive control was also predicted for the chronic headache group relative to the healthy control group. Finally, a general discussion is provided in Chapter 8, which reviews the results found in this doctoral thesis. Theoretical and clinical implications of these findings are discussed, along with suggestions for future research. Based upon the current results, a preliminary account of bias in chronic pain detailing the importance of both time-course and specificity is also presented.

## **General Methods**

The four empirical investigations conducted in the current programme of research (i.e. Experiments 1 to 4) all featured similar methodologies, whereby chronic headache and healthy control participants were recruited to a single experimental session at the University of Southampton. Due to these similarities, and to avoid repetition within this thesis, the general methods adopted by these four investigations shall be discussed here. Details specific to each experiment shall be discussed in their respective chapters.

### *Participant Recruitment and Inclusion and Exclusion Criteria*

Participants were recruited via posters and press announcements from the University of Southampton, the wider Southampton community, and UK headache-focused charitable organisations. For the experimental group inclusion criteria included: (a) suffering from primary chronic headache satisfying the criteria stated in the International Classification of Headache Disorders 2nd edition (Headache Classification Subcommittee of the International Headache Society, 2004), i.e. occurring 15 or more days per month, for more than 3 months and in the absence of medication overuse, (b) aged between 18 and 70 years (inclusive). Exclusion criteria were: (a) having been diagnosed with a psychiatric disorder within the past five years, (b) suffering from any other chronic pain including secondary chronic headaches (i.e. caused by another disorder). For the healthy control group inclusion criteria were: (a) aged between 18 and 70 (inclusive). Exclusion criteria were: (a) having been diagnosed with a psychiatric disorder within the past five years, (b) suffering from any form of chronic or regular pain (in terms of headache frequency having more than 7 headaches per month), (c) taking any psychotropic or analgesic medication on a daily basis. Confirmation that individuals satisfied the inclusion/exclusion criteria was determined prior to obtaining final consent.

### *Self-Report Measures*

The following questionnaire measures were used in each investigation to characterise the samples and to assess cognitive and emotional aspects of participants' pain experiences:

The Anxiety Sensitivity Index (ASI; Peterson & Reiss, 1992) is a sixteen-item questionnaire that assesses threatening beliefs regarding arousal symptoms. Widely used in previous chronic pain research, the ASI is conceptually distinct from trait anxiety (Sandin, Chorot & McNally, 2001), with evidence supporting its test-retest reliability (.70 for 3 years; Peterson & Reiss, 1992) and internal consistency (.87; Cox, Parker & Swinson, 1996).

The Chronic Pain Acceptance Questionnaire-Revised (CPAQ; McCracken, Vowles & Eccleston, 2004) is a 20-item self-report measure that assesses pain acceptance which refers to the willingness of the individual to live with their painful condition. McCracken et al. (2004) reported internal consistencies of .82 and .78 for Activity Engagement and Pain Willingness subscales respectively.

The Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) rates the severity of seven symptoms of anxiety and seven symptoms of depression over the previous week. The HADS was designed for use in people with physical illness as it omits the bodily symptoms of depression that may be caused by physical illness (such as loss of appetite and sleep disturbance). The HADS has been well validated by research studies, with internal consistency for anxiety and depression subscales reported at .80 and .76 respectively for the general population (Mykletun, Stordal & Dahl, 2001).

The McGill Pain Questionnaire short-form (MPQ-SF; Melzack, 1987) consists of a 15-item adjective checklist designed to assess both affective and sensory aspects of pain as well as two single-item measures of present pain intensity. The factorial validity of the sensory and affective components of the MPQ-SF has been empirically supported (internal consistency estimates for the sensory and affective dimensions .78 and .76 respectively; Wright, Asmundson & McCreary, 2001) Research has also supported the high reliability of the self-administered MPQ-SF (intra-class correlation coefficients for the subscales: total: .96, sensory: .89, affective: .89 and average pain: .88; Grafton, Foster & Wright, 2002)

The Migraine Disability Assessment (MIDAS; Stewart et al., 1999) questionnaire assesses headache-related disability. Headache sufferers answer five questions, scoring the number of days in the past 3 months they have been unable to attend work/school, social events or perform household work, along with the number of days their productivity was reduced by half when they did attend work/school and perform household tasks. The MIDAS has demonstrated good test-retest reliability

(.80), and has been shown to correlate with physicians' judgements in regards to need of medical care (.69; Stewart, Lipton, Whyte & Sawyer, 2001). In line with current clinical practice and research, the MIDAS was administered to all participants regardless of headache type (Harpole et al., 2005; Matchar et al., 2008).

The Miller Behavioral Style Scale (MBSS; Miller, 1987) assesses information-seeking (monitoring) and information-avoiding (blunting) processing styles via four stress-evoking vignettes. Individuals are required to vividly imagine each vignette, and then indicate how many of eight following coping statements they would engage in (4 monitoring, 4 blunting). Three scores can be derived from the MBSS: a total monitoring score, a total blunting score, and a sum score calculated by subtracting blunting from the monitoring total. Research has supported the internal consistency of the MBSS (.75; Petersson et al., 2002), along with the test-retest reliability of both monitoring (.72) and blunting (.75) subscales (Miller & Mischel, 1986, cited in Miller, 1987).

The Pain Coping Strategies Questionnaire (CSQ; Rosenstiel & Keefe, 1983) is a 44-item questionnaire measuring the use of different cognitive and behavioural coping strategies employed by individuals experiencing pain. The measure features six cognitive coping subscales, including diverting attention, reinterpreting pain sensations, catastrophising, ignoring sensations, praying or hoping and coping self-statements, along with the behavioural coping subscale of increasing behavioural activities. In addition, two 7-point Likert scales measure individuals' ability to successfully control and successfully decrease their pain. Based upon a three-factor model, Hill, Niven and Knussen (1995) reported alpha coefficients for coping attempts (.77), helplessness (.69) and self-efficacy (.84) factors.

The Pain Self Efficacy Questionnaire (PSEQ; Nicholas, 1989) is a 10-item questionnaire measuring the belief that activities can be performed despite the presence of pain. Research with a sample of chronic pain sufferers has provided evidence for high levels of internal consistency (0.92) along with high test-retest reliability over a period of 3 months (0.73; Nicholas, 2007).

The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushene, 1970) is a 40-item self-report measure of state and trait anxiety. Barnes, Harp and Jung (2002) explored reliability generalisation in 816 research articles employing the STAI between 1990 and 2000. Reliability coefficients showed an internal

consistency of .91 and .89 for the state and trait scales respectively. Test-retest reliability was .70 and .88 respectively.

The Twenty-Item Toronto Alexithymia Scale (TAS-20; Bagby, Parker & Taylor, 1993) is composed of 20 items organized in a stable and replicable three-factor structure congruent with the theoretical basis of alexithymia. The items are divided into difficulty describing emotions (DDE), difficulty identifying emotions (DIE) and externally-oriented thinking (EOT). The measure has good internal consistency ( $\alpha = .82$ ; Richards, Fortune, Griffiths & Main, 2005), good test-retest reliability ( $r = .74$ ; Kooiman, Spinhoven and Trijsburg, 2002), and there is evidence for its construct and criterion validity (Bagby, Taylor, Quilty & Parker, 2007).

### *Procedure*

Ethical approval for all investigations was obtained from the Research Ethics Committee of the School of Psychology, University of Southampton. All participants gave their written informed consent prior to their inclusion in the respective investigations, in compliance with regulations of the institution and the guidelines of the Helsinki Declaration, and were informed that their results would remain confidential, and that they could withdraw from the study at any time. Participants were tested in an isolated, dimly lit room (during the computer task), free from auditory or visual distraction. Participants initially completed the computer task (i.e. the visual-probe task [Experiments 1 to 3] or the emotional Stroop task [Experiment 4]). The researcher remained with the participant during the practice trials to ensure the requirements of the task were understood. Once this was established, the participant was then left alone to complete the task. Following this, participants were provided with as much time as necessary to complete the questionnaires, which were presented in a new random order to each participant. To avoid potential priming on the computer task, participants completed the self-report measures after the task (Segal & Gemar, 1997). Finally, participants were provided a verbal and paper debrief and thanked for their time.

## **Chapter 1**

### **The Nature of Pain and its Impact upon the Individual and Society**

#### **1.1. Summary**

This chapter provides a detailed discussion of the nature of pain and its numerous effects upon both the individual and society. The physiology and experience of pain is firstly briefly examined, including relevant theoretical models of pain processing. The impact of chronic pain is then assessed, with an emphasis upon the consequences experienced by patients living with such disorders. The biopsychosocial model is introduced and evaluated, which has greatly affected both theoretical conceptualisations of chronic pain and the treatments available to patients. A specific focus is then placed upon chronic headache, the disorder investigated in the current programme of research. Research investigating the prevalence of chronic headache is summarised, along with detailed information concerning the two primary headache subtypes investigated in the current research (chronic tension-type headache and chronic migraine) and their associated negative effects. Finally, a discussion of the role of coping strategies in chronic headache is provided, including trigger avoidance and pain acceptance, followed by conclusions and suggestions for future research.

#### **1.2. The Physiology and Experience of Pain**

Pain is a part of life. While definitions have varied over time, it is commonly accepted that pain is “an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage” (International Association for the Study of Pain [IASP], 1979, p.250). Pain is therefore a subjective experience, which may or may not be associated with actual physical damage. Nociception, alternatively, can be defined as “the neural processes of encoding and processing noxious stimuli” (Loeser & Treede, 2008, p.473), and is the objective physiological activity that occurs following contact with a noxious stimulus. While nociceptive activity results in the conscious perception of pain in many instances, Loeser and Treede note that this does not always occur; it is possible

for nociception to exist with no perception of pain, and vice versa. The distinction between these two terms is therefore highly important, and will be maintained throughout this doctoral thesis.

Considering the physiology of pain, Melzack and Wall (1996) argue that any theory of pain must be able to explain a number of observed facts, including the high level of variability between injury and pain; the resistance of some forms of pain to medical treatment; the different dimensions of pain; and the ability of pain to change over time. Based upon observations such as these, the gate-control theory of pain was developed, which proposes that a neural mechanism within the dorsal horn of the spinal cord, 'the gate', modulates the experience of pain. Ascending nociceptive signals from the peripheral nervous system relay information concerning noxious stimuli that have come into contact with the organism. Additionally, a fundamental aspect of this model is the proposal that signals also descend from the central nervous system, which account for the ability of cognitive and emotional factors to modulate the perception of pain (Melzack & Wall, 1965).

Both ascending and descending signals are proposed to modulate the extent to which the gate is either open or closed, influencing the conscious perception of pain. Upon publication, the gate control theory generated a large degree of debate and research (Melzack, 1999), although the notion of a gate mechanism is now generally accepted (Horn & Munafò, 1997). Advantages of this theory include emphasis placed upon the importance of the central nervous system in the pain process (Melzack, 1999), highlighting the importance of both physiological and psychological mechanisms (Horn & Munafò, 1997). However, it has also been argued that this theory fails to explain a number of important factors. For example, it has been noted that the biochemical aspects involved in neuronal activation and transmission are not explained within this theory, along with a lack of explanation concerning the pathophysiology of pain disorders (Omoigui, 2007). Despite these criticisms, the gate control theory has made a significant contribution to the understanding of pain (Horn & Munafò, 1997).

Since the gate control theory was first proposed, a great deal of knowledge has been generated in regards to the neurophysiology of pain pathways (Main, Sullivan, & Watson, 2008), with subsequent developments and refinements to theoretical models of pain. Based upon observations of pain in individuals with paraplegia and phantom limb pain, Melzack (1999; 2001) developed the neuromatrix theory of pain. Within this theory, the neuromatrix is considered a widespread

network of neurons within the brain, out of which the neurosignature develops. In turn, the neurosignature shapes the multiple dimensions of pain experience, including cognitive-evaluative, sensory-discriminative, and motivational-affective dimensions. Thus, in addition to sensory input, a host of additional factors are implicated in the experience of pain, including cultural learning, past experiences, personality, and emotional states. In support of this theory, neuroimaging studies have found evidence that pain is processed in a variety of cortical areas known as the pain matrix. Specifically, sensory-discriminative aspects of pain are associated with the primary and secondary somatosensory cortices and the lateral thalamus; the affective-emotional dimension with the anterior cingulate cortex and anterior insular cortex; and cognitive-evaluative with the prefrontal cortex (Moisset & Bouhassira, 2007). It should be noted, however, that the neuromatrix theory is not without limitations, as it may be too broad to test empirically, especially in regards to phantom limb pain (Giummarra, Gibson, Georgiou- Karistianis, & Bradshaw, 2007).

When experienced, pain may appear cruel and punishing to the individual. Despite such perceptions, pain provides strong survival value in a number of ways. Firstly, when an organism comes into contact with a noxious stimulus (such as fire) pain acts as a warning system, rapidly orienting attention towards the stimulus and promoting immediate withdrawal to minimise damage. Secondly, pain may also promote rest, which is often essential for the healing of damaged bones and joints, along with other internal injuries (Melzack & Wall, 1996). Pain is a universal evolutionary mechanism that is experienced by almost everybody to some degree at various times across the lifespan. Congenital analgesia, the inability to experience pain, is a rare exception, which often results in the individual failing to notice injuries or illnesses. The observation that such individuals typically die during childhood has often been presented as further evidence for the adaptive survival value of pain (Nagasako, Oaklander, & Dworkin, 2003).

Considering both its adaptive value and frequency of occurrence, it is not surprising that pain is one of the primary motives for seeking medical attention (Cordell et al., 2002; Todd et al., 2007). Aside from physical suffering and discomfort, pain has been repeatedly associated with many other negative consequences. Patients therefore seek medical attention not only for pain relief, but also because pain interferes with daily activities and is linked to emotional distress (Gureje, Kroff, Simon, & Gater, 1998). The experience of pain can vary considerably between individuals (Mao, 2009), including in terms of duration, intensity, and

location. Such factors are likely to affect how an individual will respond to their pain, their attempts to control their pain, and the overall impact of their pain upon daily functioning. Considering pain duration, the distinction between acute and chronic pain is of high importance. From a clinical perspective, treatments which are typically effective for acute pain do not necessarily show the same benefits when applied to chronic pain (Melzack & Wall, 1996), and therefore specific medical understanding of the latter is required. From the patient's perspective, chronic pain is likely to be associated with a range of negative effects which differ from those associated with acute pain. A discussion of chronic pain, along with its implications for both the individual and society, shall next be provided.

### **1.3. The Prevalence of Chronic Pain**

Chronic pain disorders are challenging and complex, with resulting difficulties in their definition (Holden & Pizzi, 2003). While a number of differing definitions have been proposed, basing these upon the temporal characteristics of pain alone ignores a number of other important factors, such as levels of disability and pain severity (Dunn, Croft, Main, & von Korff, 2008). The IASP defines chronic pain as that progressing beyond normal healing time (Merskey & Bogduk, 1994), which may be especially convenient considering that different injuries vary widely in regards to associated natural healing time. However, Merskey and Bogduk expand this definition by suggesting 3 months as an optimal division point between acute and chronic non-malignant pain. Chronic pain therefore contrasts temporally with acute pain, which is relatively short-term and fades quickly (Reber & Reber, 2001). Thus, while acute pain may last for only seconds or minutes, chronic pain may persist for many years or even decades.

Despite disagreements in precise definition, research has demonstrated the high prevalence of chronic pain. In Europe, an investigation examining data from 46,394 telephone interviews in 15 European countries and Israel reported 19% of the sample to suffer from chronic pain. Back pain was the most commonly reported type of pain (47%), with 15% reporting chronic head pain (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006). Figure 1.1 shows details of pain by location, along with the most commonly reported causes. Figure 1.2 reports prevalence by country, which was highest in Norway, and lowest in Spain.

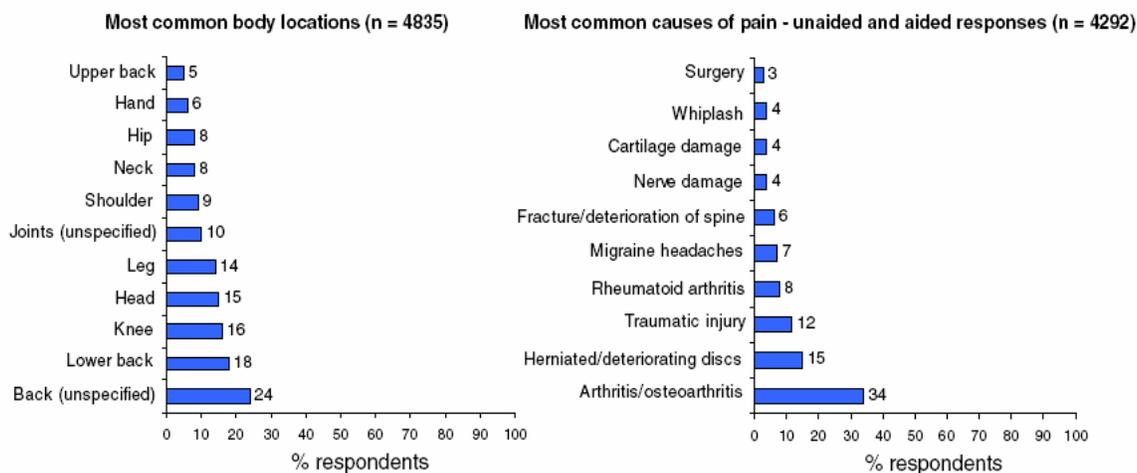


Figure 1.1. Body locations and respondents' opinions of the cause(s) of their chronic pain.

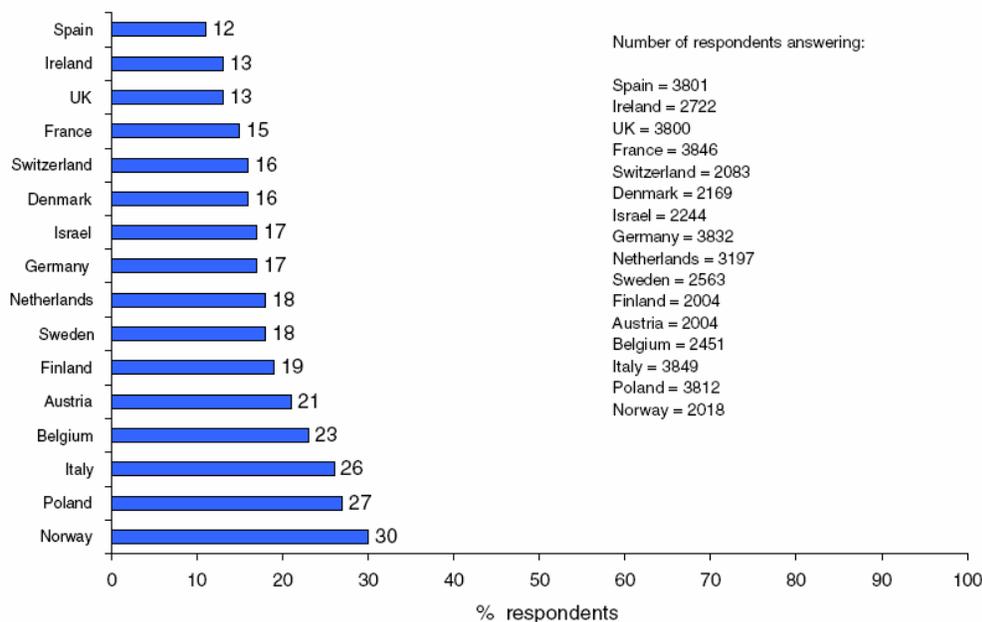


Figure 1.2. Prevalence of chronic pain from 46,394 respondents in 15 European countries and Israel

Both figures reprinted from European Journal of Pain, 10 (4). Breivik, H., Collett, B., Ventafridda, V., Cohen, R., & Gallacher, D. Survey of chronic pain in Europe: prevalence, impact on daily life, and treatment. Pages no., 287 – 333. Copyright (2006), with permission from Elsevier.

As shown, prevalence rates of chronic pain vary between countries, although in all instances are high enough to be considered a serious health problem. Further studies have supported these findings. In Australia, Blyth et al. (2001) collected data from 17,543 telephone interviews, revealing 17.1% of males and 20.0% of females to suffer from chronic pain. Analysing data from 3,605 completed questionnaires, a UK community-based study revealed 50.4% of respondents' living with chronic pain (Elliott, Smith, Penny, Smith, & Chambers, 1999). This UK prevalence was therefore considerably higher than the 13% reported by Breivik et al. (2006). However, differences may be partly attributable to variations in methodology, as telephone and postal surveys were used by Breivik et al. and Elliott et al. respectively. It has been noted that telephone interviews typically produce lower prevalence levels than postal surveys (Hardt, Jacobsen, Goldberg, Nickel, & Buchwald, 2008). It is possible that the two-way process of communication in telephone interviews allows participants to seek clarification to questions which may be confusing.

#### **1.4. The Impact of Chronic Pain upon the Individual and Society**

Despite some variation in reported figures, it is apparent that a significant number of individuals suffer from chronic pain. It is not surprising that chronic pain is therefore considered a major health-care problem (Gatchel et al., 2007). However, the problem of chronic pain itself is compounded by the wide-range of negative effects that have been commonly associated with these disorders, including those related to psychological and social well-being. Considering psychological well-being, associated issues include heightened levels of anxiety, depression, and fear of movement (Tüzün, 2007), which have been shown to be highly prevalent. Investigating patients with musculoskeletal pain, Pallant and Bailey (2005) found evidence for probable anxiety in 38.2% of cases, and probable depression in 30.1% of cases. Similarly, Thieme, Turk, and Flor (2004) found 32.2% of patients with fibromyalgia syndrome to report symptoms characteristic of anxiety disorders, while 34.8% reported symptoms characteristic of depressive disorders. Recruiting patients with rheumatoid arthritis, Zyrianova et al. (2006) found 65% of patients to exhibit evidence of depression, while 44.4% provided evidence of anxiety. Considering fear, Turk, Robinson and Burwinkle (2004) found 38.6% of patients with fibromyalgia syndrome to report fear of pain and activity. More recently, Thomas et al. (2010) reported high fear of movement in 79.6% of patients with chronic lower back pain.

In addition, high levels of anxiety were reported by 61.2% of patients, high depression by 55.1%, and high catastrophising by 65.3%.

The above research highlights the high prevalence of comorbid psychological disorders across a range of chronic pain conditions. Many of these negative consequences are also interrelated, serving to further exacerbate the problems the patient is likely to face and possibly maintain the chronic condition. For example, fear-avoidance models propose that following an acute injury, fear of pain promotes an avoidance of activity engagement, which in turn results in increased disability, depression and disuse syndrome (cardiovascular and musculoskeletal deconditioning), all of which assist in the development and maintenance of chronic pain (Vlaeyen & Linton, 2000). Chronic pain therefore does not exist as an isolated entity in the patient's life, but rather negatively affects many diverse areas, all of which may be exacerbated over time. Furthermore, diagnosing the presence of negative mood in chronic pain is highly important from a treatment perspective, as compliance and treatment motivation may be adversely affected (Gatchel et al., 2007).

Considering broader societal consequences, chronic pain has been shown to negatively affect society in a number of ways, including missed days from work, and the financial medical costs associated with treating and managing pain. Back pain, for example, has been shown to place an extensive economic burden on society. Analysing data from the 1987 National Medical Care Expenditure Survey, Rizzo, Abbott and Berger (1998) reported an annual American work productivity loss due to chronic backache at \$28 billion. Average losses per worker were calculated at \$1,230 for males and \$773 per females. Considering such figures, it has been noted that, while chronic back pain forms a small percentage of all back pain cases, it also forms the highest percentage of economic costs (Maetzel & Li, 2002). This high cost results from a number of factors, including the aforementioned missed workdays and use of medical services. While the majority of investigations have focused upon adult chronic pain, it is important to remember that chronic pain is also a significant problem in childhood. Within the United Kingdom, research investigating adolescent chronic pain suggests an economic burden of approximately £8000 per child per year (although this figure varies widely per patient) translating to an overall estimated burden of £3,840 million per year (Sleed, Eccleston, Beecham, Knapp, & Jordan, 2005).

## 1.5. The Biopsychosocial Model and Chronic Pain

Research has highlighted the negative impact chronic pain can have upon both psychological and social functioning. However, these aspects of functioning may also affect chronic pain. This notion is supported by the Biopsychosocial (BPS) model of health, which postulates that, in addition to biological factors, psychological and social factors are also implicated in disease and illness (Engel, 1977). The BPS model therefore contrasts to the traditional, and still dominant, biomedical model, which views illness as a result of underlying physical pathology only (Wade & Halligan, 2004). Supporting the BPS model, research has identified the importance of biopsychosocial factors in a range of chronic medical conditions, including epilepsy (Hermann & Jacoby, 2009; McCagh, Fisk, & Baker, 2010), cancer (Carlsen, Jensen, Jacobsen, Kraskik, & Johansen, 2005), cardiovascular disease (Figueredo, 2009), and diabetes (Herpertz et al., 2002; Strodl, & Kenardy, 2006). Considering chronic pain disorders, an understanding of psychological and social factors that may serve to cause or maintain pain is of high importance. This may be especially true when the aetiology of pain is unknown, and hence untreatable.

Research supporting the BPS model in chronic pain has emphasised the importance of both psychological (emotional and cognitive) and social factors in pain. Considering psychological factors, pain intensity and disability have been found to significantly correlate with anxiety (e.g. Meredith, Strong, & Feeney, 2006), depression (e.g. Arnstein, Caudill, Mandl, Norris, & Beasley, 1999) and anger (e.g. Okifuji, Turk, & Curran, 1999). Anxiety sensitivity has also been associated with increased fear of pain and escape/avoidance behaviours (Asmundson & Taylor, 1996; Asmundson, Norton, & Veleso, 1999), suggesting psychological factors to influence the coping strategies a patient with chronic pain may utilise. Similarly, research also suggests alexithymia (Lumley, Smith, & Longo, 2002; Huber, Suman, Biasi, & Carli, 2009) and worrying/rumination (Eccleston, Crombez, Aldrich, & Stannard, 2001) to be associated with patient functioning. Considering the latter, Eccleston et al. argue that worry is likely to be linked to increased vigilance for pain, which in turn results in negative outcomes for patient, including increased perceptions of pain severity (Goubert, Crombez, & Van Damme, 2004).

Cognitive factors are also of significance, playing important roles in both the assessment and treatment of chronic pain (Moreno, García, & Pareja, 1999). Chapter 2 provides a detailed discussion of the importance of attentional processes in pain,

which have been extensively studied in regards to pain moderation (Villemure & Bushnell, 2002). Perceived self-efficacy, including the belief that one can manage and function in spite of chronic pain, has also been shown to significantly mediate the relationship between pain intensity and disability (Arnstein et al., 1999). An individual's appraisal of their chronic pain is also an important consideration, as beliefs that pain is uncontrollable, permanent, and indicates damage, along with perceptions of disability, have all been associated with poor patient functioning (Turner, Jensen, & Romano, 2000). Furthermore, research has provided evidence to support the notion that chronic pain negatively affects aspects of executive functioning in chronic pain (Solberg Nes, Roach, & Segerstrom, 2009). Both emotional and cognitive factors are therefore associated with chronic pain functioning, although neither should be considered independent of the other (Gatchel et al., 2007). Supporting this, research has suggested cognitive appraisals of harm to be predictive of increased anxiety, and appraisals of challenge to be predictive of decreased depression in chronic pain (Herrero, Ramírez-Maestre, & González, 2008).

Considering social factors, evidence has supported the efficacy of adequate social support in chronic pain. Holtzman, Newth & Delongis (2004) found social support to affect pain severity via an encouragement of specific coping strategies. Furthermore, patient perceptions of social support were also important, with support satisfaction and disappointment associated with adaptive and maladaptive coping respectively. Further supporting the benefits of social support, Reese, Somers, Keefe, Mosley-Williams, & Lumley (in press) have provided evidence for significantly higher levels of affective pain ( $p = .006$ ) and psychological disability ( $p = .02$ ) in unmarried patients than non-distressed, married patients. However, no significant differences were found between unmarried patients and married patients with marital distress, once again suggesting quality of social support to be highly important. Chronic pain has also been associated with lower education, income and occupational class (Saastamoinen, Leino-Arjas, Laaksonen, & Lahelma, 2005), along with high job strain and organisational injustice (Saastamoinen, Laaksonen, Leino-Arjas & Lahelma, 2009), again highlighting the range of social factors implicated in such disorders.

A great deal of research has therefore highlighted the importance of psychological and social factors in chronic pain, advocating the value of adopting the BPS model in regards to such disorders. This model is likely to be beneficial when total pain relief is not possible, encouraging the implementation of a variety of

therapeutic techniques in order to improve patient functioning (Nicholas, 2008). Many pain management programmes now exist which encourage patients to actively manage their chronic pain conditions. While such programmes display variations in content, major features typically include modifications of unhelpful pain behaviours, psychological therapy, and improvements to fitness and strength (Main et al., 2008). The BPS model has therefore been of utmost importance in regards to chronic pain disorders, being described as “the most widely accepted and most heuristic perspective to the understanding and treatment of chronic pain” (Gatchel et al., 2007, p.581).

## 1.6. Chronic Headache

Headache is a common source of pain experienced by almost everybody at some point in their lives (Midgette & Scher, 2009). It is the most common reason for patient referral to a neurologist, substantially contributing to neurologist workload (Bekkelund & Salvesen, 2001). Chronic headache, the focus of the current programme of research, is a major health concern (Davis & Grassley, 2005). Research investigating the prevalence of chronic headache has highlighted the global burden of this disorder. Analysing data from 107 publications, Strover et al. (2007) reported a global chronic headache prevalence of 3%, with prevalence levels of 1.2% for males and 4.5% for females. A high number of individuals therefore live with chronic headache, which is more common in females than males. Considering individual investigations, chronic headache is prevalent in a range of geographical regions. Recruiting individuals ( $N = 2,252$ ) attending a health centre in Spain, Castillo, Muñoz, Guitera and Pascual (1999) reported a chronic headache prevalence of 4.7%, with 89.9% of those meeting a diagnosis being female. Thus, 8.7% of the female sample (compared to 1% of the male sample) suffered from chronic headache. The average age of chronic headache onset was 44 years ( $SD$  18 years). From an initial sample of 10,585 participants, an investigation of chronic headache in the French population estimated a prevalence of 2.98%, which was once again higher in females (4.18%) than males (1.62%) (Lantëri-Minet et al., 2003). The mean age of participants with chronic headache was 43.2 years ( $SD$  17.1). Most recently, a Norwegian investigation of 30,000 individuals between the ages of 33 and 44 years revealed a one-year chronic headache prevalence of 2.9% (Grande, Aaseth, Gulbrandsen, Lundqvist, & Russell, 2008).

The above research therefore shows chronic headache to be a widespread problem. Patients with chronic headache have noted the negative impacts this condition has upon their lives, which can be unpredictable, difficult to control and impedes daily functioning (Leiper, Elliott, & Hannaford, 2006). The notion that such disorders result in serious disability for both the individual and their family (Jensen & Stovner, 2008) is therefore unsurprising. In many instances, however, medical investigation does not reveal any identifiable underlying structural disease (Pascual, Colás, & Castillo, 2001), which are classified by the International Classification Subcommittee of the International Headache Society (2004) as primary headaches. Secondary headaches, alternatively, are those caused by another disorder. Due to their relevance to the current programme of research, only tension type and migraine primary headaches will be discussed below. In both instances, reported diagnostic criteria is as that specified in the International Classification of Headache Disorders (ICHD-II) (International Classification Subcommittee of the International Headache Society, 2004). Cluster headache is third headache subtype, which is considered the most severe and rarest of the primary headaches (Russell, 2004). However, as patients with this type of headache were not recruited in the current research, this subtype shall not be considered any further.

### *Tension-Type Headache*

Tension-type headache is characterised by a bilateral pain that is typically mild to moderate in pain intensity. The pain is often described as a steady pressing, tightening or constricting sensation around the head, which is not accompanied by nausea or vomiting. Chronic tension-type headache is classified as occurring 15 or more days a month, for more than 3 months, which may either last for hours or persist continuously. They may be accompanied by no more than one of nausea, photophobia (sensitivity to light) or phonophobia (sensitivity to noise). If nausea is present, then this is neither moderate nor severe, and is not characterised by vomiting (International Classification Subcommittee of the International Headache Society, 2004).

Tension-type headaches are the most prevalent of the primary headache subtypes, and have been speculated to be the most common form of pain experienced (Ulrich, Russell, Jensen, & Olesen, 1996). Tension-type headaches are also the most common form of chronic headache. In the investigation by Castillo et al. (1998) described above, 47.2% of all chronic headache cases were tension-type. As with all

forms of chronic headache, the presence of chronic tension-type headache has been shown to impact many areas of life. For example, psychiatric co-morbidities have been extensively investigated in relation to tension-type headache, with evidence supporting the presence of anxiety and depression in a high number of individuals who experience such headaches (Lipchik & Penzein, 2004). Investigating psychosocial correlates, Holroyd et al. (2000) recruited 245 patients with chronic tension-type headache and 89 healthy control participants. Participants were subjected to an assessment, including the keeping of a headache diary, interview and questionnaires. The results of this investigation revealed an anxiety diagnosis in 17% of headache patients, and a depression diagnosis in 21% of patients. Considering differences between groups, significantly higher levels of trait anxiety, depression and daily stress (all  $p < .001$ ) were reported by the headache patients compared to healthy controls. Such research highlights the impact that chronic tension-type headache can have upon psychological functioning. It should also be noted that physical, social and role functioning were also significantly lower in the patients than the controls ( $p < .001$ ), with 62% showing impairment on all three scales (compared to 9% of healthy controls).

### *Migraine Headache*

Migraine headache is characterised by a unilateral pulsating pain that is typically moderate to severe in pain intensity. Unlike tension-type headache, physical exercise is known to aggravate or possibly cause such symptoms, and additional symptoms include at least one of nausea, vomiting, photophobia and phonophobia. Individuals may also experience aura, which is classified as a perceptual disturbance, and may include visual symptoms, (e.g. flickering lights), sensory symptoms (e.g. pins and needles) or speech disturbances. Such disturbances do not persist following the migraine and are fully reversible. Similar to tension-type headache, chronic migraine headache is classified as occurring 15 or more days per month, for more than 3 months. Chronic migraines are not associated with symptoms of aura (International Classification Subcommittee of the International Headache Society, 2004).

Migraine is a major health concern, having heavy impacts upon both individual and society. Estimates have suggested American employers lose approximately \$13 billion per year as a result of sick days and impaired work functioning attributable to migraine (Hu, Markson, Lipton, Stewart & Berger, 1999).

Such a societal burden is likely compounded by the fact that many migraine sufferers continue to experience the effects of their condition even on non-migraine days. For example, investigating functioning over a two-day, non-migraine period, migraine sufferers reported significantly more sleepiness during both mornings and evenings, and significantly less vigour throughout the whole day, than non-migraine participants (*p*-values not provided in article). Additionally, significantly lower levels of dynamic activity were reported during the afternoon ( $p < .02$ ) and evening ( $p < .01$ ) by the migraine sufferers (Stronkes, Tulen, Bussmann, Mulder, & Passchier, 2004). Additional research has suggested only 43% of migraine patients return to normal daily functioning between migraines (Linde & Dahlof, 2004). The severity of migraine is highlighted by such research which suggests that, even between attacks, patients' lives can still be negatively affected in a range of differing ways.

Chronic migraine has often been associated with a number of physical and psychiatric comorbidities (Pompili et al., 2009). Assessing 54 patients with chronic migraine, Corchs et al. (2006) found 87.5% of their sample to suffer from at least one psychological illness. Specifically, 28.6% met criteria for major depression, while 44.6% suffered from at least one anxiety disorder. Additionally, 60.7% of the sample met criteria for phobic anxious disorder. Another investigation assessing 63 patients found high levels of fatigue in 84.1% of the sample, with 66.7% meeting the diagnostic criteria for chronic fatigue syndrome (Peres, Zuckerman, Young, & Silberstein, 2002). Results such as these support the notion that individuals with chronic migraine are at risk from numerous comorbidities, all of which are likely to lead to further impacts upon quality of life.

### **1.7. The Impact of Chronic Headache upon Daily Functioning**

While the implications of chronic headache upon daily functioning have been noted, it is important to examine this in further detail. Considering differences between episodic and chronic headaches, a large amount of research has supported the notion of the latter having more severe implications upon daily functioning than the former. Ferrari et al. (2007) investigated similarities and differences between participants with episodic migraine ( $n = 100$ ) and those with a diagnosis of chronic migraine attributable to probable medication overuse ( $n = 150$ ). The results revealed a number of differing characteristics between the two groups, including higher levels of unemployment in individuals with chronic migraine ( $p < .001$ ). Comorbid

disorders were also significantly higher in individuals with chronic migraine, including psychiatric disorders (both anxiety and depression being the highest;  $p < .001$ ), hypertension ( $p < .001$ ), gastrointestinal ( $p < .001$ ) and musculoskeletal disorders ( $p < .001$ ), among others. Poor sleep ( $p < .05$ ) and constipation ( $p < .001$ ) were also higher in chronic migraine patients. These results provide evidence for the increased difficulties chronic migraine patients may experience over episodic migraine sufferers. Additionally, the results also suggest that the presence of chronic migraine may also have a number of negative affects upon family members, as hypertension ( $p < .05$ ), heart problems ( $p < .05$ ) and migraine ( $p < .05$ ) were significantly higher in first degree-relatives of chronic migraine patients (although the possibility of a genetic vulnerability should also be considered). Furthermore, drug and/or alcohol abuse was significantly higher in chronic migraine relatives ( $p < .05$ ).

Further research has supported the wide-ranging effects of chronic headache. Analysing data from 380 patients, Maizels and Burchette (2004) found patients with chronic migraine to report significantly more somatic symptoms than patients with episodic migraine ( $p < .001$ ). Specifically, significantly higher levels of insomnia ( $p < .05$ ), bowel problems ( $p < .05$ ) and stomach ( $p < .01$ ) and back ( $p < .01$ ) pain were reported. Tietjen et al. (2007) conducted a questionnaire-based investigation with 1,032 females suffering from headache, including 593 episodic and 439 chronic patients. Significantly lower levels of household income ( $p < .001$ ) and less formal education ( $p < .001$ ) were reported by patients with chronic headache compared to patients with episodic headache. Additionally, significantly more patients with chronic headache reported they were bothered by additional complaints, including stomach and back pain, dizziness, difficulties sleeping and lack of energy (all  $p < .001$ ) among others. Considering such research, evidence has supported the notion that chronic headache can be more debilitating than episodic headache. Impairments in psychological and physical functioning have been reported, along with negative financial and occupational impacts, demonstrating the wide-ranging implications of chronic headache. Furthermore, these negative effects are likely to impact family members also, and may therefore result in further problems for both the patient and their relatives.

### *Similarities and Differences between Chronic Headache Subtypes*

While differences between episodic and chronic headache have been considered, it is important to also consider differences between subtypes of chronic headache. As noted earlier, chronic migraine and tension-type headache vary in a number of important ways, including associated symptoms, pain severity, and duration. Despite this, relatively few published investigations have examined how different headache subtypes affect patient functioning. Investigating psychiatric comorbidity and associated symptoms, Mongini et al. (2006) performed a psychological assessment on 506 headache patients, including 102 with chronic migraine and 90 with chronic tension-type headache. In addition, 80 healthy controls were also included. While comorbid symptoms were significantly higher in headache patients than healthy controls ( $p < .001$ ), no significant differences between the two chronic headache groups were found in regards to anxiety, depression or associated physical symptoms. Other research has also failed to find significant differences between chronic tension-type headache and chronic migraine. Guitera, Muñoz, Castillo, & Pascual (2002) found no significant differences between patients with chronic tension headache ( $n = 50$ ) and transformed migraine ( $n = 37$ ) in regards to quality of life. Considering adolescents, Wang, Juang, Fuh, & Lu (2007) reported no significant differences between chronic migraine ( $n = 28$ ) and chronic tension-type headache ( $n = 73$ ) patients in regards to psychiatric comorbidity. Maizels and Burchette (2004) also found no significant difference between patients with chronic migraine and those with chronic daily headache in regards to the frequency of associated somatic symptoms.

Although the above studies found no evidence for significant difference between these two subtypes of chronic headache, other research has found evidence for differences. Mongini, Ciccone, Deregibus, Ferrero, and Mongini (2004) collected data from 459 patients suffering from either chronic or episodic headache/migraine (including 97 with chronic migraine and 83 with chronic tension-type headache). Significantly higher levels of anxiety and depression were reported by chronic migraine patients compared to other patient groups, including chronic tension-type headache. Furthermore, anxiety and depression were significantly associated with chronic migraine only ( $p < .001$ ). In another investigation, Wang, Fuh, Lu, and Juang (2001) found patients with transformed migraine ( $n = 310$ ) to report significantly poorer quality of life than those with chronic tension-type headache ( $n = 231$ ).

Considered overall, inconsistent results have been reported concerning similarities and differences between chronic headache subtypes in regards to patient functioning. It is possible that different sample characteristics and recruitment methods are responsible for this inconsistency. Furthermore, it is notable that classification of headache subtypes varies to some extent between studies. Specifically, the classification of transformed migraine is not identical chronic migraine outlined in the ICHD-II, as the former requires regular migraine (i.e. 15 or more days per month) for at least one month, and the latter for more than 3 months. Thus, it may be unreliable to compare the results of investigations adopting differing classification criteria. Further research is therefore necessary in this area, exploring the importance of specific sample characteristics and classifications. It is common, however, for psychosocial studies to combine both subtypes into a single chronic daily headache sample (e.g. Scher, Stewart, Ricci, & Lipton, 2003; Seshia, Phillips, & Baeyer, 2008). Such practice may stem from the fact that the majority of researchers consider these two headache subtypes not as discrete entities, but as opposite ends of a continuum (Martin, 1993).

Establishing whether comorbid disorders are present in individuals with chronic headache is an important consideration, regardless of headache subtype. Regarding psychological comorbidities, untreated or undiagnosed depressive disorders can have a negative impact upon headache treatment. As finding effective treatments can involve trial and error with medications and doses, some patients with depression may abandon the use of medication during such modifications. In contrast, patients with comorbid anxiety may become so fearful of experiencing a headache that they overmedicate themselves, which itself may have serious health implications. Alternatively, patients may experience anxiety when thinking about side-effects of medication, therefore choosing not to take them when needed (Baskin, Lipchik, & Smitherman, 2006). These examples highlight a number of potential ways through which mood disorders may negatively impact the treatment of chronic headache. However, it is important to note that patient fears may not be entirely illogical, as anxieties concerning negative side-effects of medication may be based upon prior medication experiences. One again, the importance of considering chronic headache in regards to the BPS model is highlighted.

## 1.8. Coping with Chronic Headache

Living with a chronic pain disorder is a challenging demand met with varying degrees of success. While some patients exhibit adjustment difficulties, others adapt successfully, adopting healthy and beneficial coping strategies that allow them to function relatively well (ter Kuile, Spinhoven, Linssen, & van Houwelingen, 1995). As with all forms of chronic pain, the selection and maintenance of successful coping strategies is of high importance in chronic headache, especially when headaches are resistant to medication. One such strategy frequently adopted is the avoidance of headache triggers; factors or situations that increase the likelihood of the patient developing a headache. Research has highlighted the high number of triggers associated with headache, and in particular migraine. In a sample of 1,207 patients, Kelman (2007) found 75.9% to report at least one trigger for their migraine, with the mean number of identifiable triggers being 6.7. While avoidance may therefore appear to be a sound strategy, Kelman (2007) has argued avoidance of all triggers to be both unrealistic and stress-inducing, the latter of which is itself a very commonly reported trigger. Reviewing the literature, Martin and MacLeod (2009) have noted other commonly reported triggers to include menstruation, hunger, fatigue, noise, weather conditions, sex, smoking, alcohol, and specific foods. Noting the little empirical support for trigger avoidance, these authors purport clinical advice of avoidance to be unwise, despite the frequency with which it is recommended. Indeed, avoidance of all potential triggers is likely to place severe limitations upon the patient's life, leading to further problems.

Further to the above, a number of additional coping strategies have been linked to chronic headache. Radat et al. (2008) utilised data from a large scale survey of the French population, including 1,127 individuals with episodic migraine and 407 with chronic daily headache with migrainous features (CDH-M). Significantly higher levels of catastrophising and avoidance were reported by the CDH-M group, who also demonstrated significantly greater external locus of control (all  $p < .001$ ). The researchers therefore noted that individuals with CDH-M are more likely to utilise maladaptive coping in regards to their pain. In addition, higher social support seeking and emotional expression were also reported by the CDH-M group ( $p < .001$ ). Although this may appear proactive, the authors argue this to be maladaptive for the patient due to associations with helplessness and reliance upon others. Considering functioning, significantly higher levels of emotional distress were reported by the

CDH-M group ( $p < .001$ ). Overall, the results from this study are suggestive that individuals with chronic headache are more likely to adopt unhelpful, maladaptive coping strategies, which may be associated with negative outcomes. In contrast, no significant differences between the two groups were found in regards to adaptive strategies (e.g. positive reinterpretation). While a number of negative coping strategies are therefore implicated in the chronicity of migraine, caution should be noted in the interpretation of these results, as the cross-sectional design precludes inferences regarding causality.

As highlighted, selection of coping strategies is highly important in chronic headache, with inappropriate strategies potentially associated with negative effects. The results of Radat et al. (2008) also raise the importance of considering variations in pain characteristics, which are likely to influence the coping strategies adopted. Additional research includes that of Spinhoven, Jochems, Linssen, and Bogaards (1991) who, in a sample of 111 patients with chronic tension-type headache, found reduced active coping in patients with shorter daily pain periods. Siniatchkin, Riabus, and Hasenbring (1999) investigated coping differences between patients with different types of headache ( $n = 90$ ). Patients with chronic daily headache evolved from migraine reported significantly higher catastrophising than patients with chronic tension-type headache ( $p = .0004$ ), along with significantly higher seeking of social support ( $p < .001$ ). Considering tension-type headache only, those with chronic headache were significantly more likely to cope by avoiding social situations than those with episodic headache ( $p = .0005$ ). In another investigation, Rollnik, Karst, Fink, and Dengler (2001) recruited patients with episodic ( $n = 37$ ) and chronic ( $n = 52$ ) tension-type headache, who were required to keep a four-week headache diary. Differences in coping strategies were found between the two groups, with chronic patients reporting significantly greater consoling with religion ( $p = .028$ ) and denying/wishful thinking ( $p = .039$ ). However, depression was significantly correlated with both ( $p = .037$  and  $p < .001$  respectively), suggesting such strategies to be maladaptive in chronic headache.

While the above research has emphasised negative coping, individuals with chronic headache may experience more beneficial effects from pain acceptance, which refers to an individual's willingness to live with the presence of chronic pain. Due to the sometimes unpredictable and uncontrollable nature of chronic headache, acceptance may prove more valuable than continued attempts at control or cure (McCracken, 1998). Supporting this, McCracken & Eccleston (2003) recruited 230

patients with chronic pain (including 4.8% with head or face pain), who completed a series of questionnaire measures including those of coping, acceptance, and disability. Acceptance was significantly correlated with reduced levels of pain intensity, depression, pain-related anxiety, and physical and psychological disability, along with significantly increased work status and uptime (all  $p < .001$ ). Considering specific coping strategies, little evidence was found to support beneficial effects of any strategy measured, although ignoring pain was correlated with decreased pain-related anxiety, and coping self-statements correlated with decreased depression (both  $p < .05$ ). In contrast, numerous notable negative correlations were found. For example, diverting attention was significantly correlated with increased pain intensity, physical disability, and pain-related anxiety (all  $p < .001$ ), increased depression and psychosocial disability (both  $p < .01$ ), and decreased work status ( $p < .01$ ) and uptime ( $p < .05$ ).

Confirmation of the above findings has been reported in a number of subsequent studies, supporting the beneficial effects of pain acceptance upon patient functioning and reduced suffering (e.g. McCracken, Gauntlett-Gilbert & Eccleston, 2010; McCracken & Zhao-O'Brian, 2010). However, a notable limitation is the recruitment of patients with heterogeneous forms of chronic pain in such investigations, of which chronic headache typically only forms a small subset. To date, no published research has explicitly investigated the effectiveness of acceptance in chronic headache, which is therefore needed before firm conclusions can be drawn. In addition, longitudinal research is needed to investigate the long-term implications of different coping strategies, including how they may be related to the transition of acute to chronic headache (Radat et al. 2008). Despite this need for further research, the importance of adopting appropriate coping strategies in chronic headache is readily apparent, and provides support for the adoption of the BPS model in regards to such disorders. Indeed, both cognitive and behavioral interventions have proven effective in the treatment of headache disorders, although considerable room for growth exists in regards to such therapies (Rains, Penzien, McCrory & Gray, 2005).

## **1.9. Conclusions**

Chronic pain disorders are highly prevalent (Breivik et al., 2006), with a wealth of evidence showing the extensive burden placed upon patients living with

such conditions. In addition to coping with physical pain and discomfort, patients must also contend with a range of associated psychological, social, occupational, and financial consequences, all of which may be interrelated. Support has been provided for the BPS model of illness (Engel, 1977), as a range of psychosocial factors have been implicated in the development, maintenance, and experience of chronic pain. Such factors include perceived self-efficacy and perceived disability, along with emotional vulnerabilities such as anxiety and depression, and attentional processes which will be discussed in detail in the next chapter. Overall, an understanding of psychological and social factors is of theoretical and clinical significance in chronic pain disorders, and should be taken into consideration when investigating models accounting for the development and maintenance of pain and relevant therapeutic interventions. Chronic headache is a relatively common form of chronic pain, which may lead to serious disability for both the patient and their family (Jensen & Stovner, 2008). Standard pharmacological interventions for chronic headache may be ineffective alone (Lipchik & Nash, 2002), which coupled with the unpredictability associated with these disorders (Leiper et al. 2006), further highlights the range of problems that may be experienced by patients. A detailed understanding of how psychosocial factors, including attention, are implicated in the development and maintenance of chronic headache is therefore warranted, and are considered in the current programme of research.

## **Chapter 2**

### **Attentional Processes in Acute and Chronic Pain**

#### **2.1 Summary**

This chapter critically evaluates the relationship between attentional processes and pain perception. Following an introduction into the area, an outline of attention is provided, followed by a specific focus upon visual attention. Relevant theoretical models of attention and pain are then presented, including those predicting bias towards somatic pain sensations and pain-related information. Theories of emotional processing are also discussed, along with their relation to the attention/pain relationship. Evidence for the effects of pain in attentional performance is then evaluated for both acute and chronic pain, followed by a discussion of the modulation of pain via different attentional techniques. Finally, a summary is provided, discussing the possibilities for future research in the area of attentional bias in chronic pain.

#### **2.2 Introduction**

The relationship between attention and pain has been the subject of considerable research over the past several decades, and remains one of the most thoroughly studied areas within the pain literature (Brown & Jones, 2008). Arguably, this high degree of research has resulted from both clinical and theoretical interests in this relationship. The majority of such research has typically made use of one of two methodologies; either pain-free individuals are subjected to acute levels of pain and their responses monitored, or the performance of chronic pain patients on cognitive tasks are observed (McCracken, 1997).

The results from such research have been influential in the development of theoretical models of pain, including the cognitive-affective model of the interruptive function of pain (Eccleston & Crombez, 1999), the Schema Enmeshment Model of Pain (Pincus & Morley, 2001), the Misdirected Problem-Solving Model (Eccleston & Crombez, 2007), numerous fear-avoidance models (e.g. Vlaeyen & Linton, 2000), and the motivational account of attention to pain (Van Damme, Legrain, Vogt, and Crombez, 2010), which are discussed in detail below. Such results have also been

used to develop and refine treatment strategies for individuals suffering from pain. For example, Cognitive Behavioural Therapy (CBT) is now a commonly used form of psychological treatment for chronic pain, which often includes aspects related to processes of attention (McCracken, 2007a).

For a noxious stimulus to be perceived as painful, a conscious, functioning cortex is required. Indeed, pain is only argued to exist when an individual perceives it as so (Bromm, 1995). Increasing research has highlighted the notion that multiple cortical areas are involved in the perception and processing of pain (Treede, Aarian, Bromm, Greenspan & Lenz, 2000). Sensory-discriminative aspects of pain have been associated with the primary and secondary somatosensory cortices and the lateral thalamus; affective-emotional dimension with the anterior cingulate cortex and anterior insular cortex; and cognitive-evaluative with the prefrontal cortex (Moisset & Bouhassira, 2007). As such, the notion of pain as a linear process is no longer commonly held, with modulation of pain deemed possible at a number of neural stages (Petrovic & Ingvar, 2002), including the dorsal horn of the spinal cord (Melzack & Wall, 1965; 1996) and the brainstem (Petrovic, Petersson, Hansson, & Ingvar, 2004). Additionally, the brain itself has also been implicated in the modulation of pain via cognitive mechanisms (Petrovic & Ingvar, 2002), including those of attention.

### **2.3. The Role of Attention in Contemporary Research and its Relationship to Pain**

A large body of research into the various facets of attention currently exists, although considerable debate remains over how to best define attention. Despite this, attention has often been defined as a selectivity of processing (Eysenck & Keane, 2000), allowing an organism to focus upon specific information in the environment, while attempting to ignore information deemed irrelevant (Reber & Reber, 2001). It is unlikely, however, that a single definition of attention will ever be agreed upon. Indeed, such a definition may be of little practical use, considering the notion that attention is not a single process, but encompasses a variety of processes (Styles, 2006). However attention may be conceptualised, limitations in attentional and cognitive resources have been clearly shown in humans (Styles, 2006), and a number of influential theoretical models have attempted to explain the reasons for such limitations (e.g. Broadbent, 1958; Kahnemen, 1973). As discussed below, the

concept of limited attentional resources has important implications in regards to pain, which itself demands a significant portion of such resources (Eccleston & Crombez, 1999).

In addition to the effects of resource limitations, the relationship between attention and pain has been investigated from other perspectives. Similar to the processing of pain, numerous cortical regions have been implicated during attentional processes. Neuroimaging studies have provided evidence for the importance of a fronto-parietal cortical network in both overt and covert attention, which has been especially linked to shifting of visual attention (de Haan, Morgan, & Rorden, 2008). During top-down attentional control, activity has been shown in numerous cortical regions, including the limbic cortex, basal ganglia, superior colliculus, pulvinar nucleus (Knudsen, 2007), the left interparietal sulcus, bilateral precuneus, and superior frontal sulci (Hanh, Ross, & Stein, 2006), among others. Of particular importance, however, is the observation of cortical overlap in attention and pain processing. Specifically, the anterior cingulate cortex, thalamus, posterior parietal cortex, and dorsolateral prefrontal cortex have been implicated in both pain and attention (Bantick et al. 2002). Such findings therefore provide a neuroscience based explanation for the cognitive modulation of pain, as discussed later in this chapter.

A further perspective on the attention/pain relationship has been the investigation of attentional biases, which can be defined as “differential attention towards threatening compared to neutral stimuli” (Cisler, Bacon, & Williams, 2009. p228). Increased research over the past decade has examined how the presentation of pain-related information affects attentional allocation in both pain-free individuals and patients with chronic pain. Such research has typically made use of two cognitive paradigms; the visual-probe task and the emotional Stroop task. Considering the visual-probe task, Study 1 (Chapter 3) provides a systematic review of controlled research investigating biases in chronic pain patients, along with a discussion of research investigating biases in pain-free samples only. Experiment 2 (Chapter 5) provides a discussion of former uncontrolled research exploring biases in chronic pain samples only. Finally, past research utilising the emotional Stroop task to investigate biases in chronic pain samples is described and evaluated in Experiment 4 (Chapter 7).

## 2.4. Processes of Visual Attention

Vision serves an important function for many organisms, providing information about the contents of their local surroundings (Yantis, 2004). At any one time, there is a wealth of visual information available to the organism, much of which will be irrelevant to current behaviours. Processes of visual attention allow the organism to select information which is relevant, while filtering out information that is irrelevant (Van der Stigchel et al., 2009). How information is selected for visual processing has been the source of considerable debate and research. Concerning this, an important distinction has been made between goal-driven and stimulus-driven attentional control. Goal-driven control is a top-down process whereby the individual's intentions and strategies determine the environmental stimuli that are selected for visual attention. Stimulus-driven control, alternatively, is a bottom-up process whereby part of the visual scene captures attention regardless of the individual's current goals (Yantis, 2004). Numerous theories have been developed based upon these two forms of selection, including those focusing upon goal-driven control (e.g. Bacon & Egeth, 1994), and stimulus-driven control (e.g. Itti & Koch, 2000). However, it has been argued that any instance of visual attention will typically involve both forms of control, and that "the deployment of attention in an image is determined by an interaction between the properties of the image and the observer's set of attentional control" (Yantis, 2004, p 253). A second important distinction is that between preattentive and attentive processing. According to Van der Stigchel et al. (2009):

Preattentive processing occurs prior to the allocation of focal attention, has a large capacity and occurs in parallel fashion across the whole visual field. Attentive processing, however, has a small capacity and occurs only for a part of the visual field. (p. 202).

Research investigating attentional bias in a range of disorders has examined the distinction between these two stages of attention, including research into chronic pain bias (e.g. Asmundson, Wright, & Hadjistavropoulos, 2005; Boyer et al., 2006). Furthermore, it may be necessary for future chronic pain research to more fully explore the conscious, attentive stage of processing. Allport (1989) has stated that the attentional system must serve two important, but conflicting, functions. Firstly, there

is a need for organisms to monitor their environments, shifting their attention quickly between current activities and information deemed relevant to safety and survival. Thus, this system must be able to interrupt current attentional processes, triggering attentional orientation. Secondly, there is a need for organisms to sustain their attentional focus upon current activities, which will need varying times for completion (e.g. eating, mating). The attentional system must also be capable of maintaining attentional focus. A balance, therefore, is needed between orienting and maintenance of attention. To date, little research examining attentional bias in chronic pain has investigated the distinction between these two stages. LaBerge (1995) has further proposed that motivational variables are more likely to influence maintenance of attention than initial orienting. This has important implications for the relationship between attention and pain, as Van Damme et al. (2010) have argued motivational factors to influence bias towards both pain and pain-related information (discussed below). This important area is therefore addressed in the current programme of research.

## **2.5. Theoretical Models of Attention and Pain**

A number of theoretical models have highlighted the relationship between attentional processes and pain. Although these models differ in a number of important ways, all support the notion that pain is designed to interrupt and demand attention, with subsequent consequences upon functioning. A discussion of models relevant to the current area of research will now be provided.

### *A Cognitive-Affective Model of the Interruptive Function of Pain*

Eccleston and Crombez's (1999) cognitive-affective model emphasises the role of attention in the perception of pain, which is based upon three fundamental principles. Firstly, the presence of pain initiates behaviours of escape. Secondly, pain demands and captures attention. Thirdly, the ability of pain to interrupt attention is influenced by a number of important variables, including pain characteristics such as intensity and novelty, along with additional factors such as emotional arousal. Prior to the experience of pain, this model presents the individual within an environment of multiple non-painful demands, of which only some will gain access to the individual's *sensory system*. Of the demands that do gain access, only some will elicit attentional engagement; others (e.g. posture) simply do not enter conscious

awareness and hence do not capture attention. Therefore, of all these demands, one may gain dominance as the *focal task* (e.g. reading a book) the individual is consciously engaged in. Continuing focus upon this task is achieved by continuous feedback from both the *sensors* and *action programs*. When a noxious demand impinges upon the senses, a number of changes occur, including an interruption of the *focal task*. Additionally, other actions are also likely to be interrupted. The *action programs* that allowed concentration on the former *focal task* are now stopped, being replaced by those prioritising the removal of pain. In this situation, threat and pain have therefore demanded attention. Importantly, however, a number of factors can moderate the extent to which this occurs, including pain intensity, novelty and predictability, along with individual difference variables including catastrophic thinking. The success of the escape behaviours is determined by feedback from both *sensory inputs* and *action programs*.

The cognitive-affective model describes the interruptive function of physical pain sensations upon attention, supporting the notion that pain is an evolutionarily primed mechanism adapted for survival. This pattern of behaviour describes the experience of acute pain. However, it is noted that this process continues within chronic pain, and therefore “chronic pain means chronic interruption of current attentional engagement” (Eccleston & Crombez, 1999, p. 363). Contrary to reflecting an abnormal response, chronic interruption is therefore regarded by this model as a normal response to pain, despite the wide range of negative implications this may have. Eccleston and Crombez’s cognitive-affective model has been highly influential in both acute and chronic pain research, emphasising how and why pain captures attentional resources. However, this model is arguably over-simplistic, as it does not explicitly state how moderators of the pain-attention relationship work, or the precise relationship of such moderators to a) one another, and b) perceptions of pain-related threat. Furthermore, while this model predicts interruption from sensory pain, it does not allow for prediction as to when or why pain-related information may also capture attention.

### *Fear Avoidance Models*

Over the past several decades, fear-avoidance models of pain have become increasingly popular among researchers and clinicians, with numerous models now in existence. Such models have focused primarily upon various forms of chronic musculoskeletal pain, including lower back pain (e.g. Smeets, van Geel & Verbunt,

2009) and chronic whiplash (Nieto, Miró & Huguet, 2009). While minor differences exist between the various models, a common principle shared is that fearful reactions to pain, pain anticipation, or perceived pain consequences promotes a withdrawal from activities or behaviours believed to result in an increase in pain (Norton & Asmundson, 2003). As such, fear-avoidance models provide a theoretical account of how acute pain problems can develop into chronic, persistent pain.

To provide more detail, Vlaeyen and Linton's (2000) fear-avoidance model of chronic musculoskeletal pain posits that, following acute pain from injury, an individual may react in one of two ways. If an individual does not interpret their pain experience as threatening, they are likely to engage in initial rest, followed by a steady increase of activity until normal functioning can be resumed (i.e. the injury has healed). Alternatively, an individual may catastrophise about their pain, believing it to be an indication of a serious problem. As a consequence, pain-related fear evolves, which itself leads to a hypervigilance for bodily sensations, along with an avoidance of activities or behaviours that are believed to increase pain. Due to such avoidance, disability arises, which may additionally translate into negative musculoskeletal and cardiovascular impacts (i.e. disuse syndrome). Negative psychological effects, including increased depression, may also arise. In such an instance, an individual is likely to become locked in a vicious circle, whereby any new painful sensation is once again interpreted as threatening, continuing the cycle of disability.

Reviewing the increasing amount of research testing the fear avoidance model, Leeuw et al. (2007) note accumulating support for the model's various components and predictions. In regards to attentional bias, Vlaeyen and Linton (2000) note that their model allows for the prediction that difficulties disengaging from pain-related material will be shown in patients with high levels of pain-related fear. Supporting this, Dehghani, Sharpe, and Nicholas (2004) found heterogeneous chronic pain patients to show significant reductions in attentional bias for pain-related information following a CBT programme, which was predicted by changes in fear of movement. Although the model focuses upon musculoskeletal pain, this particular prediction may be applicable to other forms of chronic pain, including chronic headache, the focus of the current doctoral thesis. However, an important limitation here is that this model only focuses upon hypervigilance to pain, and does not consider the role of different stages of attention (e.g. initial orienting vs. maintained attention).

### *Schema Enmeshment Model of Pain*

Based upon a review of information-processing biases in pain, the Schema Enmeshment Model of Pain (SEMP; Pincus & Morley, 2001) highlights the importance of both chronic pain and affective states in determining whether an individual will demonstrate cognitive bias towards pain-related information. Central to this model is the concept of interrelated schemas, which have been defined as “functional structures of relatively enduring representations of prior knowledge and experience” (Beck & Clark, 1988, p.24). According to the SEMP, repeated simultaneous activation of two schemata may result in enmeshment, wherein information from one becomes integrated into the other. In such situations, negative effects may arise as a consequence. The three schemata of key importance in this model include those of *pain*, *illness*, and *self*. The *pain* schema contains information regarding the sensory dimensions of pain, including physical and temporal characteristics. The *illness* schema contains information pertaining to the consequences of illness, including potential negative affects upon daily functioning and quality of life. In addition, information concerning the timeline, causes and control of illness are also included. Pincus and Morley note that individuals are likely to hold different schemata for different illnesses. Finally, the *self* schema is considered more complex, containing information relevant to the individual. Of importance is a self-evaluation system, which appraises the self in regards to behaviours and feelings.

The degree of enmeshment observed for any one patient is likely to be linked to overall coping. An individual coping well with their chronic pain will have relatively little enmeshment of *pain* and *self* schemata, retaining a sense of self-worth not impinged by their medical condition. Such individuals are not distressed or depressed by their condition. In contrast, individuals with all three schemata heavily enmeshed develop a sense of identity closely linked with their medical condition, with associated distress and depression likely. An important feature of the SEMP model is the notion that the type of cognitive bias observed will depend upon a number of key factors, including the degree of schemata enmeshment, the presence of depression and the history of depression. An important notion is that all patients, regardless of associated distress or enmeshment, will demonstrate bias towards sensory pain information. For chronic pain patients with no current or previous history of depression, this is the only type of self-referent information biases are predicted towards. In contrast, patients with current depression are also predicted to

bias towards illness and affective information, the latter of which is linked to emotions such as anxiety and anger. Finally, biases towards depressive information (self-referent perceptions of worthlessness) are predicted in patients with both a history of depression and current depression. Should the patient have no current depression the vulnerability remains, and biases are only predicted when a negative mood is induced.

An advantage of the SEMP model is the specific focus upon bias towards pain-related information, along with the emphasis it places upon the importance of patient distress and depression, with bias predicted to differ depending upon these variables and schemata enmeshment. Chronic pain is a highly heterogeneous group of disorders (Fitzgibbon et al., 2010), and therefore different patterns of cognitive bias may be evident between patients. Furthermore, a distinction between depression, which refers to negative self-perceptions, and affective distress, which refers to negative perceptions concerning the patient's situation, is argued to be of clinical importance. Despite these advantages, the concept of schema enmeshment is derived from post-hoc observations of prior research, with no independent evidence for this process provided (Morley, Davis & Barton, 2005). In addition, Morley (2010) has recently noted that whilst the concept of *self* is regarded as a unitary entity, alternative theories, such as self-discrepancy theory, highlight the notion that individuals may hold a numerous different perspectives of *self*. Despite these limitations, the SEMP model may prove useful in attentional bias research, although to date has received little attention in this field.

#### *The Misdirected Problem-Solving Model*

Eccleston and Crombez's (2007) Misdirected Problem-Solving Model (MPSM) emphasises the role pain-related worries may have upon chronic pain. An individual with chronic pain is likely to demonstrate a number of pain-related worries, including those related to the causes and consequences of pain. In everyday life, worry may in certain instances be associated with beneficial effects, encouraging the individual to search for a solution to their particular problems. For individuals with chronic pain disorders, however, this search may be maladaptive if, despite repeated attempts, no successful solution is found. In such an instance, the individual may enter into a perseverance loop. Specifically, pain-related worries are argued to result in hypervigilance for pain and pain cues, which itself leads to pain interruption and further worries. Worry is further argued to result in pain being primarily framed

as a biomedical problem, resulting in solutions aimed at removing pain. When such solutions are successful, both pain and worry abate. If unsuccessful, however, worry is increased. A subsequent perseverance loop may then develop, leading to increased perseverance to find a successful solution. One consequence of this loop is that the individual's problem frame often becomes narrowed, with increased effort expended on the goal of pain removal. It is argued, however, that such a narrowing may in fact assist in the maintenance of the patient's suffering, and can therefore be considered misdirected. Reframing the problem may therefore be more beneficial to the patient, enabling them to refocus their efforts upon effectively living with their pain condition, as opposed to repeated unsuccessful attempts at finding a cure to what may be an incurable condition.

The notion that pain-related worries are associated with a hypervigilance for pain is an important one, supporting the view that attentional processes are implicated in the maintenance of pain. Likely due to its relatively recent publication date, little empirical research has investigated the specific components of the MPSM. Longitudinal research is especially needed, however, which will allow for an investigation into the concept that worry plays a significant role in the hypothesised perseverance loop. In regards to the current programme of research, it should be noted that the MPSM does not expand in great detail upon the role of hypervigilance, although it is stated that worry may be associated with a hypervigilance for both pain and pain-related cues. However, similar limitations to those associated with fear avoidance models can be raised, in that the MPSM does not address the importance of different stages of attentional processing, or offer predictions as to when pain-related cues will or will not capture attention.

#### *The Motivational Account of Attention to Pain*

One limitation of many theoretical models of attention and pain is the lack of consideration given to the individual's motivational state. Highlighting this, Van Damme et al. (2010) have recently proposed a motivational account of attention to pain, which states that attention can be motivated by both basic desires (e.g. food, reproduction) and concrete goals (e.g. specific task requirements). At any one time, an individual is likely to have multiple goals, of which one may be prioritized as the focal goal. As goals can conflict with one another, this focal goal will be shielded from other goals to enable its completion. Pain, however, is argued to capture attention in two ways. Firstly, pain is evolutionarily primed to capture attention to aid

survival, and therefore demands attention in bottom-up fashion. Importantly, however, both characteristics of pain and the focal goal may influence the degree to which this attentional capture occurs. Secondly, the individual may consciously prioritise pain as the focal goal via top-down mechanisms (e.g. attempts at pain control). Should this occur, increased attentional processing of both pain and pain-related information is to be expected.

Considering attentional bias, Van Damme et al. (2010) argue that, while models such as the SEMP predict hypervigilance for pain-related information in chronic pain patients compared to healthy controls, inconsistent evidence has been found (this body of research is systematically reviewed in Study 1). The importance of the patient's motivational account is therefore emphasised, which may provide an explanation for such inconsistent findings. Due to the recentness of this publication, no published research has empirically tested this account. A potential limitation of this account, however, is the lack of consideration given to a patient's adopted coping strategies, the selection of which has been linked to motivational factors (Van Damme, Crombez, & Eccleston, 2008). Coping strategies may also be related to attentional bias in chronic pain (as investigated in the current programme of research), and therefore an understanding of this relationship is important in regards to this theoretical account.

#### *Evaluation of Theoretical Models of Attention and Pain*

The theoretical models discussed above consider the relationship between attention and pain, and are all supportive of the notion that pain demands attentional resources. Fear avoidance models, the MPSM, and the motivational account of attention to pain, also note a hypervigilance for pain-related cues and information. None of these models, however, expand upon the precise nature of these cues, or how relevant they need to be for hypervigilance to be shown. The SEMP, alternatively, provides much more detailed information regarding the types of information biases are expected towards, allowing for the testing of a number of specific predictions. Little research exploring attentional bias in pain has addressed this model however, which is surprising considering its publication nearly a decade ago. Overall, it is apparent that none of the theoretical models of pain and attention address every facet relevant to attention and attentional bias in pain. Perhaps the most notable limitation is the lack of information regarding different stages of attention (i.e. preattentive vs. attentive; initial orienting vs. maintained attention).

Future models of attention and pain will therefore need to address the importance of these different attention stages, which have been shown to be important in the time-course of attentional biases in emotional disorders such as anxiety and depression (Mogg & Bradley, 1998).

## 2.6. Theories of Emotional Processing

While not developed specifically for pain, theoretical models of emotional processing also lend themselves to the prediction that individuals with chronic pain should demonstrate cognitive bias towards pain-related information. One such account, Bower's network model (Bower, 1981; Gilligan & Bower, 1984), proposes the existence of information processing biases associated with emotionally congruent information. Within this model, both emotions and information are represented as nodes within a semantic network. Importantly, nodes are conceptualised as being linked to other nodes within the network. For example, an emotion node of sadness may be linked with nodes representing despair, hopelessness and loss. Thus, when an emotion node is activated (either internally or externally via certain stimuli), a spread of activation occurs to other associated nodes. As a result, information processing becomes biased towards emotionally congruent information.

While this model was developed in regards to emotions and moods, it is also likely to be of importance to pain, which is considered to be both a sensory *and* emotional experience (International Association for the Study of Pain [IASP], 1979). As discussed in Chapter 1, chronic pain has been associated with numerous negative emotional experiences, including anxiety (e.g. Meredith, Strong & Feeney, 2006), depression (e.g. Arnstein, Caudill, Mandle, Norris & Beasley, 1999) and anger (e.g. Okifuji, Turk & Curran, 1999). The experience of chronic pain may therefore lead to activation of nodes associated with the sensory and affective experiences of pain, with resulting biases towards such information. Indeed, as discussed throughout this thesis, attentional biases in chronic pain have typically been examined in relation to sensory and affective pain information (e.g. Lioffi, Schoth, Bradley, & Mogg, 2009). An important consideration raised by the network model is whether information processing biases in individuals with chronic pain are more likely to be demonstrated during the actual presence of pain. This question has received little empirical investigation, and will be addressed within the current programme of research.

Schema theories also support the notion that individuals should demonstrate cognitive biases towards information associated with their concerns, including Beck's schema theory (Beck & Clark, 1997; Beck, Emery & Greenberg, 1985). It has been argued, however, that such accounts typically offer only a limited view of cognition, neglecting "broader aspects such as attention, regulation of cognition, levels of control of processing and interactions between varieties of processing" (Wells & Matthews, 1996. p. 881). Based upon these limitations, Wells and Matthews (1994; 1996) developed the Self-Regulatory Executive Function Model (S-REF). This model seeks to integrate Beck's theory within a comprehensive information-processing framework, conceptualising how cognitive processes may be involved in the onset and maintenance of emotional disorders.

The cognitive framework within the S-REF model comprises three interacting levels of cognition, including a) automatic processing, b) controlled processing, and c) stored knowledge/self-beliefs. Considered in turn, automatic processing is a low-level form of cognition which is stimulus-driven and operates outside of conscious awareness. Demands upon the individual's attentional resources are therefore minimal. Controlled processing, alternatively, is voluntary and dependant upon attentional resources. The individual is typically aware of a level of conscious control over such processes (including his or her actions and thoughts). Finally, long-term memory contains a body of stored knowledge and self-beliefs, which feature plans for cognitive processing. Controlled processing is argued to be dependant upon the individual's stored knowledge and self-beliefs. Within this three-levelled cognitive architecture, the individual may engage in a variety of cognitive processes known as "configurations". According to Wells (2000):

The configuration most relevant to psychological disorder is the S-REF configuration, which is intimately linked to self-relevant processing. It serves a goal-directed executive function of reducing self-discrepancies between a representation of the current status of the self and a desired or "normative" representation (pp. 17 – 18).

A resulting feature of the S-REF configuration is increased focus upon the self, with appraisal concerning the significance of both internal (i.e., bodily signals and meta-cognition of one's own thoughts) and external events. While this configuration is typically of short-duration, it may become maintained in those with

emotional disorders. Of relevance to the current thesis, one consequence of this maintained focus is the emergence of cognitive bias for relevant information, with Wells and Matthews (1994; 1996) placing specific focus on attentional bias. Following automatic, low-level processing of information, the S-REF configuration may be engaged. This process is argued to affect the individual's focus of attention in the short-term, and in the long-term may also increase the sensitivity of the individual to detect such information (i.e., lead to processes of hypervigilance). For individuals with chronic pain, there may be a discrepancy between the current self-representation (i.e., with pain) and the normative representation (i.e., without pain), with difficulties in achieving the self-regulatory goal of removing pain. As a result, S-REF activity persists, resulting in cognitive bias for pain-related information.

As noted, an advantage of the S-REF model is the focus placed upon multiple components of cognitive processing and their interactions. Coping strategies or plans may influence attentional processes. Rumination is particularly problematic, which “continuously primes dysfunctional self-beliefs and lower level representations of belief-congruent units. This reduces thresholds for intrusion of congruent information in consciousness” (Wells & Matthews, 1996, p. 882). Furthermore, the S-REF model supports the notion that individuals may demonstrate attentional avoidance of relevant information by strategically engaging in processes such as diverting attention. Such predictions are of particular relevance to the current programme of research, which investigates attentional bias via the visual-probe task (Study 1, and Experiments 1 to 3). Specifically, this paradigm provides valuable information on both attentional bias towards, and avoidance of, information congruent with the individual's emotional concerns.

While developed in relation to disorders such as anxiety and depression, theories of emotional processing may also be used to predict information-processing biases in chronic pain. Bower's (1981) network model has been criticised, however, for its simplified conceptualisation of both moods and cognitions, which differ markedly although are both represented as nodes (Eysenck, & Keane, 2000). Despite this, Bower's model raises questions regarding the effects of concurrent pain upon cognitive biases, which are important to address. Wells and Matthews (1994; 1996) provide a much more detailed account of cognition in their S-REF model, although the specific predictions they raise, including the importance of rumination and other coping strategies upon attentional processes, have yet to be fully addressed in chronic

pain attentional bias research. Overall, both theoretical accounts may therefore prove useful in the current programme of research.

## **2.7. The Influence of Induced Acute Pain upon Attentional Performance**

Pain has an extensively intrusive quality, which provides an important survival mechanism for the organism. In the case of acute pain, this quality ensures that the organism directs its attention towards the noxious stimulus it has come into contact with, prompting immediate action to be taken in order to prevent permanent damage or death (Melzack & Wall, 1996). In such instances, the benefits of pain can be readily understood. As discussed above, theoretical models of pain and attention have highlighted the notion that pain demands attentional resources, with subsequent effects upon concurrent task performance (e.g. Eccleston and Crombez, 1999; Van Damme et al., 2010). Supporting this, Crombez, Eccleston, Baeyens and Ellen (1996) investigated the interference effects of painful (acute electrical stimulus) and non-painful (image of a human face) distractors upon task performance (both distractors were presented for 2 seconds). Twenty-six healthy participants were recruited, who were required to discriminate between low and high auditory tones. The acute pain stimulus was found to significantly disrupt performance, with slower task response times shown with painful distractors compared to non-painful distractors ( $p < .04$ ). However, such differences were only significant 100ms following distractor onset ( $p < .01$ ), with no differences found 1500ms after onset, or 1000ms after distractor offset.

Research has therefore shown acute pain to demand attentional resources, although temporal factors of pain appear to be important in such processes. Crombez et al. (1996) argue these findings to support the notion that initial attentional capture of pain is a rapid and automatic process, which may be subsequently subjected to voluntarily control. In addition to pain duration, research has found other variables to influence the degree to which acute pain captures attention, including the interpretation of pain. Crombez, Eccleston, Baeyens and Eelen (1998a) adopted a primary-task paradigm similar to that used by Crombez et al. (1996) described above (i.e. a tone-discriminating task with concurrent painful and non-painful distractor stimuli). Prior to the experiment, all participants ( $N = 38$ ) were familiarised with the painful stimuli. However, while the control group were informed that the intensity of the stimuli during the experiment would be no higher, participants allocated to the

threat group were falsely told that highly painful stimuli of greater intensity would be produced at random points. In actuality, both groups experienced the same level of pain stimulation. The results firstly showed significantly greater interference from the painful distractor stimuli, compared to the non-painful distractor, 250ms ( $p < .01$ ) and 750ms ( $p < .05$ ) after stimulus onset, but not 250ms after stimulus offset (as measured via tone-discrimination response time). Considering the threat value of pain, participants receiving threatening instructions demonstrated significantly poorer performance on the tone discrimination task 250ms after the onset of the painful stimulus ( $p < .001$ ), compared to the control group. However, significant differences between these two groups were not found at any other stimulus presentation time.

The above investigations have provided evidence that the introduction of a novel, painful stimulus captures attention, although detrimental performance upon concurrent attention-demanding tasks is influenced by both the characteristics and interpretation of pain. Further research from Crombez and colleagues has identified catastrophic thinking to also affect inference from pain. Reporting the results of two investigations using a similar primary-task paradigm, Crombez, Eccleston, Baeyens and Eelen (1998b) provide evidence that catastrophisers show significantly greater interference than non-catastrophisers on a tone-discrimination task 250ms after pain stimulus onset ( $p < .001$ ). Vancleef and Peters (2006) have supported these findings, showing catastrophising scores to significantly correlate with pain interference on a similar tone discrimination task in a sample of 48 healthy participants.

It is important to note that not all research has supported the above findings. Veldhuijzen, Kenemans, de Bruin, Olivier, and Volkerts (2006) investigated the effects of acute pain from a cold pressor task upon visual search task performance in 22 pain-free participants. Participants were required to search for a specific letter among a group of non-target letters, while their non-dominant hand was placed in either painfully cold (average temperature 2°C) or neutral temperature (average temperature 27°C) water. High (6 letters) and low (2 letters) cognitive load trials were presented to participants randomly. The results of this experiment found no significant effect of pain upon performance, with participants performing equally well under both cold and neutral water temperatures. Additionally, a second experiment ( $N = 14$ ) featured a similar task, albeit the two cognitive load conditions were presented in separate blocks. Once again, pain was not found to significantly affect task performance. It is important to note, however, that this research used

experimentally induced pain of relatively long duration. In the investigations described above utilising the primary-task paradigm, interference was only found during the initial onset of pain. It is possible that top-down cognitive processes were employed by participants to minimise the interruptive effects of pain. However, a limitation of this study is that measures of individual differences were not collected, and it is therefore unknown as to whether factors such as catastrophic thinking would have influenced pain interference in this case.

Overall, research investigating the interference of acute pain upon attention-demanding tasks has typically provided evidence for interruptive effects of pain, although this appears to be most strongly associated with initial pain onset. It has been noted, however, that further research in this area is necessary, as relatively few studies investigating attention on acute or episodic pain currently exist (Moore, Keogh, & Eccleston, 2009), with the majority of such research investigating chronic pain. Finally, most studies investigating the relationship between attentional processes and acute pain has been conducted in laboratory settings, where pain is highly controlled. In contrast, pain experienced in clinical settings is likely to be less controlled and more unpredictable. Caution is therefore warranted in the generalisation of results from laboratory based studies to clinical settings.

## **2.8. The Influence of Chronic Pain upon Laboratory Based and Real-World Attention-Demanding Tasks**

While the attention-demanding nature of pain is beneficial in regards to acute pain (Melzack & Wall, 1996), such benefits largely disappear when considering chronic, intractable pain. In such instances, the survival value of pain has long since disappeared (Ridson, Eccleston, Crombez, & McCracken, 2003), with pain becoming an unwelcome burden that interferes in many areas of life (Grisart, Van der Linden & Bastin, 2007). The relationship between chronic pain and attention has been subjected to much research, which has used a variety of methods and paradigms, including cognitive experiments and more complex neuroimaging studies. Such research has provided consistent evidence for the impact of chronic pain upon cognitive functioning, with the argument being raised that an understanding of such problems is essential in the successful treatment of patients (Hart, Martelli & Zasler, 2000).

Memory is a form of cognition that requires varying degrees of attention, depending upon precise task requirements. As such, the influence of chronic pain upon attentional resources has often been examined via investigations employing memory tasks. Supportive evidence for memory deficits in chronic pain patients has been provided from a number of sources. Grace, Nielson, Hopkins and Berg (1999) compared memory performance in 30 patients with fibromyalgia (characterised by widespread musculoskeletal pain) with 30 healthy, pain-free controls. All participants were required to complete a series of measures testing for memory, attention and concentration. Compared to the healthy controls, the results showed fibromyalgia patients to perform significantly worse on the general memory index of the Wechsler Memory Scale (Wechsler, 1987) ( $p < .02$ ). Subsequent analysis of the scale sub-components revealed significantly poorer performance on both verbal memory ( $p < .02$ ) and delayed recall ( $p < .03$ ), whilst differences on visual memory approached significance ( $p < .09$ ). Further analysis revealed patients with fibromyalgia to perceive themselves as having poorer memory than healthy controls ( $p < .0001$ ).

The results of Grace et al. (1999) provide evidence that individuals with chronic pain not only demonstrate deficits in memory compared to healthy controls, but that they are also aware of these deficits. It has been argued, however, that more in-depth investigation is needed into the underlying processes of such deficits, as this knowledge will help identify the specific problems patients may face. Based upon this argument, Grisart et al. (2007) recruited 30 patients with chronic pain and 30 healthy controls, who completed a yes-no word recognition test. In order to more fully examine the underlying processes of memory involved, a remember/know procedure was implemented. A series of emotionally neutral words were presented, which participants were required to read aloud and memorise. Fifteen-minutes following this, another word set, containing an equal amount of target words and false lures, was presented. The task of the participants was to highlight as many words as they could from the original list. In addition, participants were also required to distinguish their responses between words *remembered*, i.e. a recollection of the encoding, and words *known*, i.e. a feeling of familiarity, but no recollection of the actual encoding process. Considering overall performance, chronic pain participants displayed poorer memory, producing significantly less target words (i.e. those formally presented) than healthy controls ( $p < .01$ ). Additionally, analysis on the remember/know procedure also revealed significant differences, with chronic pain

patients providing significantly less *remembered* words ( $p < .01$ ), and significantly more *known* words ( $p < .01$ ) than controls.

The results of Grisart et al. (2007) are therefore not only supportive of previous research, demonstrating the existence of general memory deficits in individuals with chronic pain, but also highlight the precise aspects of memory affected. Specifically, it is the contextual details associated with the encoding process (e.g. where one was, what they specifically thought) that appear to be affected. The fact that chronic pain participants reported significantly more *known* responses than controls is interesting. One possible explanation is that the increase of *known* responses was simply an artefact of the reduced *remembered* responses. Thus, participants with chronic pain may still possess a familiarity of previous material (i.e. *knowing*), but the attention-demanding aspects of their pain leads to a deficit in the most demanding aspects of memory (i.e. recalling of contextual information).

A limitation of the research reported thus far is that, although deficits in memory have been reported, such studies have not considered whether the presence of pain results in different effects during the encoding (attention) and recognition (memory) phases. Highlighting this trend in previous research, Kuhajda, Thorn, Klinger and Rubin (2002) developed a novel paradigm where the influence of pain presence upon these two stages was explicitly tested. Eighty participants with a medical diagnosis of either recurrent acute tension-type or migraine headache (mean average 13.08 years of condition) were recruited. During an encoding session, participants rated the valence of 30 positive and 30 negative words. Memory for these words was tested in a separate session (1 to 7 days later) in a recognition test. A total of 120 words were presented, including the 60 formally rated and 60 false lures, with the participants' task being to state whether each word appeared in the former task. For this investigation, participants were split into 4 groups, including pain during both encoding and retrieval, pain during encoding/no pain during retrieval, no pain during encoding/pain during retrieval and finally no pain during either encoding or retrieval. The results showed a significant main effect of headache pain during recognition, as participants with concurrent pain remembered significantly less accurate words than those without pain ( $p < .04$ ). In contrast, the presence of pain during the encoding phase had no significant affect upon later retrieval.

The results of Kuhajda et al. (2002) are argued to support the notion of a limited attentional capacity. While only headache pain during the recognition phase was shown to negatively affect performance, this phase is arguably more difficult

than the encoding phase, and therefore places greater demands upon attentional resources. Thus, attentional capacity is more likely to have been exceeded during this phase, resulting in memory deficits. However, Kuhajda et al. (2002) further argue that the deficits in memory observed did not result from issues of interference with memory retrieval, but rather with participants' ability to pay attention during the retrieval phase. It should be noted, however, that this conclusion remains speculation, something the authors themselves highlight.

Research investigating chronic pain patients has provided evidence that chronic pain interferes with attention demanding tasks, again supporting theoretical notions that pain demands attention (e.g. Eccleston & Crombez, 1999). Similar to research manipulating experimentally induced, acute pain, investigation into chronic pain has also considered psychological factors that may mediate the relationship between pain and attention. Eccleston, Crombez, Aldrich and Stannard (2001) found evidence for the influence of worry upon attention. Specifically, 34 participants with chronic pain were required to keep a diary over a 7-day period, detailing any episodes of worry they may experience. For each episode, ratings were made concerning a number of factors, including how attention-demanding, distracting and distressing each worry was. The results showed the presence of more reported pain-related worries than non-pain related worries (57.3% and 42.7% respectively). Pain-related worries were reported to be significantly more attention-grabbing, distracting, difficult to dismiss, intrusive, distressing, and less pleasant (*ps* variable, all  $p < .05$ ) than non-pain related worries. These results highlight the notion that, while pain characteristics themselves may be attention-grabbing, worrying thoughts about pain may further increase these demands. However, a number of limitations concerning this study should be addressed. Firstly, the lack of a healthy control group prevents the ability to establish whether the frequency of non-pain related worries were similar or perhaps higher than those found in the general population. One consequence of heightened pain-related worries may be to facilitate an increase in general worries. However, the fact that pain-related worry characteristics did not significantly correlate with a questionnaire measure of trait worrying (the Penn State Worry Questionnaire; Meyer, Miller, & Metzger, 1990) suggests otherwise. Despite this, a healthy control group would have been advantageous. A second limitation is that the process of diary-keeping may have contributed to worrying thoughts itself. For example, reading about past worrying thoughts may re-trigger such worries.

Considering the research discussed thus far, it is apparent that the presence of chronic pain may result in detrimental performances in a variety of daily activities, especially when such activities place a high demand upon attentional resources. However, while laboratory-based investigations provide revealing information, paradigms with higher levels of ecological validity are necessary in order to establish how individuals with chronic pain cope during everyday life. It is possible that certain coping strategies adopted during daily tasks are not considered or allowed for in laboratory studies, perhaps resulting in an overestimation of daily impairment arising from chronic pain. One common daily activity requiring a high degree of attention is driving. Investigating this, Veldhuijzen, van Wijck et al. (2006) examined differences in highway driving performance between 14 patients with chronic pain and 14 healthy control participants. All participants were required to perform a standardised driving test, which involved driving along a 100 kilometre highway track in the presence of a qualified driving instructor. Participants were informed that they were to maintain a steady position in their lane of traffic, whilst driving at an approximate speed of 95 km/h. The test car was fitted with a camera, which recorded the entire journey, along with the cars lateral position in relation to the lane-separating road line. From this recording, each participant's standard deviation of lateral position (SDLP) was calculated, which provides an overall indication of driving ability. The results from this investigation found significantly poorer driving in chronic pain than healthy participants ( $p = .007$ ), as measured via the SDLP. A more in-depth look into this data revealed these differences to be consistent throughout the entire journey. Considering subjective ratings, participants with chronic pain provided significantly lower driving quality ratings ( $p = 009$ ), indicating that they were aware of their reduced performance.

In addition to the driving test, participants were required to also complete a series of laboratory based measures. The results of these found no significant difference between the two groups on measures of divided attention or memory. These findings raise important questions, as performance in laboratory based tasks may not be wholly related to performance of real-world tasks. Secondly, subjective ratings of pain-intensity in the chronic pain group were not significantly related to driving performance. One consequence of this is that even individuals with low levels of current pain intensity may show deficits in driving ability. While pain intensity has been argued to impact the degree of interference shown (Eccleston & Crombez, 1999), a number of studies, (i.e. Veldhuijzen, Kenemans et al., 2006;

Kuhajda et al., 2002) suggest that this may not hold in all instances. Further research into this area is needed, however, especially that investigating the impact of chronic pain and pain characteristics upon performance of real-world tasks such as driving.

Overall, research investigating attention and chronic pain has provided similar results to those found with experimentally induced, acute pain. Pain has been shown in numerous investigations to demand attention, although characteristics such as intensity are not necessarily predictive of performance on attention-demanding tasks (Veldhuijzen et al., 2006; Kuhajda et al., 2002). This is an important finding, suggesting that it may be beneficial to offer cognitive interventions to all patients, rather than just those with high levels of pain intensity. Indeed, the cognitive modulation of pain is an important area, having been subjected to a great deal of research.

### **2.9. The Effects of Cognitive Modulation upon the Experience of Pain**

The research discussed above has provided evidence for the effects of both acute and chronic pain upon attention-demanding cognitive tasks. This relationship is not a one-way process, however, with research also investigating the clinical benefits of attentional modification upon perceptions of pain. Distraction is one of the most commonly used attentional tools by individuals experiencing pain (Johnson, 2005), and forms a strong component within many cognitive behavioural therapy (CBT) packages (Morley, Shapiro & Biggs, 2004). During such techniques, attention is diverted away from pain sensations, with either a redirection of attention made, or involvement in a distractor task (Fernandez, 1986). A number of studies have supported the efficacy of this attentional technique. Johnson and Petrie (1997) recruited 20 participants with chronic back pain, who completed two step-up exercise tasks that temporarily increased their pain. During one of these tasks, participants were also required to complete a distracting word-shadowing exercise. Compared to completing the step-up task alone, participants made significantly more steps ( $p < .05$ ) and spent significantly longer ( $p < .05$ ) engaged in the task when also concurrently performing the word-shadowing exercise. It is important to note, however, that characteristics of distraction tasks may be important in determining their effectiveness. Buck and Morley (2006) investigated the use of attentional strategies in 26 cancer patients experiencing pain (mean duration 51.46 months), who were required to keep diaries over a ten-day period. While no significant correlations

were found between diverting attention and pain, the interestingness ( $p < .001$ ), importance ( $p < .05$ ), and pleasantness ( $p < .05$ ) of distractions positively correlated with both perceived pain control and perceived ability to decrease pain. Additionally, these three factors were also significantly correlated with increased positive affect (all  $p < .001$ ). Further to studies with adults with chronic pain, a number of meta-analyses have provided evidence for the benefits of distraction in children experiencing acute pain from medical procedures (Kleiber & Harper, 1999; Uman, Chambers, McGrath, & Kisley, 2006).

In contrast to attentional distraction, focusing attention upon pain has been associated with negative results. In the investigation of Buck and Morley (2006) discussed above, a significant negative correlation was found between focusing attention on pain and negative affect ( $p < .05$ ). Further research has supported such findings. Nouwen and colleagues (Nouwen, Cloutier, Kappas, Warbrick & Sheffield, 2006) found chronic back pain patients to report significantly higher levels of pain intensity ( $p = .0001$ ) and discomfort ( $p = .0009$ ) when using attentional pain-focusing techniques during a cold-pressor task. Additionally, significantly more patients adopting the focused attention technique were unable to complete this task when compared to patients adopting the distraction techniques ( $p = .003$ ). However, difficulties arise when generalising the results of attentional strategies adopted in experimentally induced pain to those utilised in with chronic pain. Despite this, results such as these suggest that focused attention may not be effective for those with chronic pain disorders.

Overall, research has supported the notion that perceptions of pain can be modulated via attentional techniques. Research investigating attentional biases in chronic pain may also be of relevance to this notion. Specifically, evidence of bias towards pain-related information may be associated with the adoption of pain-related attentional focusing strategies. Avoidance of pain information, alternatively, may be associated with the use pain distraction techniques. As a result, it is possible that paradigms of attentional bias may provide an indication of a patient's general pain coping strategies, along with their respective benefits and disadvantages. To date, however, no published research has examined this, and therefore remains an important avenue for future investigation.

## 2.10. Conclusions

Numerous theoretical models of attention highlight the fact that humans possess limited attentional resources (e.g. Broadbent, 1958; Kahnemen, 1973). Such limitations have important consequences for individuals experiencing pain, which itself captures and demands a significant portion of these resources (Eccleston & Crombez, 1999). Highlighting this, detrimental effects upon performance of attention-demanding tasks have been found in individuals experiencing both acute (e.g. Crombez et al., 1996) and chronic (e.g. Kuhajda et al., 2002; Veldhuijzen, van Wijck et al. 2006) pain. The relationship between attention and pain has also been demonstrated via investigations of cognitive modulation of pain, which have supporting the efficacy of attentional distraction in both adults (e.g. Johnson & Petrie, 1997) and children (e.g. Uman, et al., 2006) experiencing pain. Based upon this relationship, a number of theoretical models of attention and pain predict attentional biases towards pain (i.e. Pincus & Morley, 2001; Vlaeyen & Linton, 2000; Eccleston & Crombez, 2007; Van Damme et al., 2010). Importantly, these models also predict attentional biases towards pain-related information and cues, which also place demands upon limited attentional resources. Limitations with these models have been noted, however, which fail to consider the importance of different attentional stages (e.g. initial orienting and maintained attention) upon such biases. Despite this, investigation of attentional bias in chronic pain patients has increased over the past decade, although inconsistent results currently exist (Van Damme et al., 2010). Clarification of these results is therefore important for theoretical reasons. Furthermore, as cognitive biases may provide an indication of patient functioning (Pincus & Morley, 2001), clarification may also be of clinical benefit. Considering this, the following chapter (Study 1) will provide a systematic review and meta-analysis of results from former investigations to use a specific paradigm (i.e. the visual-probe task) in the investigation of chronic pain attentional biases.

## **Chapter 3**

### **Study 1: Attentional bias towards pain-related information in chronic pain; a systematic review and meta-analysis of visual-probe investigations.**

#### **3.1. Summary**

This chapter reports a systematic review and meta-analysis of the literature which has examined the presence of attentional bias in individuals with chronic pain via the visual-probe task. A definition of attentional bias is firstly provided, along with arguments supporting the importance of investigating this form of cognitive bias in relation to chronic pain. The visual-probe task is then described. Due to its relevance to this doctoral thesis, research that has investigated pain-related biases in healthy, pain-free samples is then discussed and evaluated. Following this, a systematic review of all controlled chronic pain research employing the visual probe paradigm in this area is provided, including a meta-analysis of all relevant controlled studies investigating bias during the initial orienting of attention. While mixed evidence for attentional biases in chronic pain patients has been reported by individual studies, the results of this meta-analysis show stronger biases in individuals with chronic pain compared to healthy controls. Methodological variables, however, are shown to be important, as a sensitivity-analysis (i.e. removal of one study which differed methodologically from the others) revealed only trend evidence for bias. Implications of these findings are discussed, including proposals for future research exploring the time-course and specificity of attentional bias in chronic pain.

#### **3.2. Introduction**

Theories of emotional processing, including Wells and Matthews' (1994; 1996) Self-Regulatory Executive Function Model (S-REF) and Bower's network model (1981), emphasise the presence of information-processing biases associated with relevant, emotional information congruent with an individual's concerns. Such theories have encouraged a wealth of research into cognitive biases in emotional disorders. In addition, increasing research has also investigated cognitive biases in

chronic pain, with evidence supporting the presence of interpretation and memory biases in such populations (Pincus & Morley, 2001). While attentional biases are also predicted by theoretical models of pain and attention (e.g. Pincus & Morley, 2001), research has provided inconsistent support for this notion. Further research is therefore necessary investigating attentional bias in chronic pain.

An attentional bias may be defined as a “differential attention towards threatening compared to neutral stimuli” (Cisler, Bacon, & Williams, 2009. p228). Such biases have been typically studied in relation to threat, whereby differential processing of threatening material is evident over neutral material (Mogg & Bradley, 1998; Cisler & Koster, 2010). A large body of research has supported the presence of such biases in anxiety disorders (for a recent meta-analysis, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg & van IJzendoorn, 2007), whereby individuals with high anxiety selectively attend towards stimuli associated with their emotional fears. The investigation of attentional bias is of considerable importance, as they are likely to influence both the development and maintenance of emotional disorders (Mogg & Bradley, 1998). Specifically, it is argued that attentional vigilance for threatening information results in a greater likelihood of detecting potential sources of such threat, a factor which serves to exacerbate anxiety (Bradley, Mogg, Falla & Hamilton, 1998).

The role of attention has been extensively investigated in relation to pain, and research supports attentional modification as beneficial for chronic pain patients (e.g. Johnson & Petrie, 1997). Similar to its role in emotional disorders, attentional biases in chronic pain may assist in the causation and/or maintenance of a number of associated problems. For example, while avoidance of pain-related stimuli may be beneficial in distracting an individual from their chronic pain condition, an alternative possibility is that such individuals may underestimate the impact of pain cues, leading to an increased likelihood of experiencing further pain or re-injury as a result of overexertion (Asmundson, Kuperos & Norton, 1997). In contrast, although vigilance towards pain-related stimuli or cues has been argued to be beneficial for survival in acute pain, such benefits largely disappear when considering chronic pain (Grisart, Van der Linden & Bastin, 2007). Excessive vigilance towards pain-related stimuli may therefore result in preoccupation with pain, resulting in a tendency for such individuals to avoid activities or situations deemed threatening to their chronic pain (Dehghani, Sharpe & Nicholas, 2004). The investigation of attentional bias in

chronic pain is therefore an important area of research, as cognitive biases are likely to have a range of theoretical and clinical implications (Pincus & Morley, 2001).

Previous research investigating the relationship between attentional bias and chronic pain has typically made use of two distinct paradigms: the emotional Stroop task and the visual-probe task. The former has provided some evidence that individuals with chronic pain show attentional bias towards pain-related information, which is discussed in depth in Chapter 7. While the emotional Stroop task can be considered a more traditional measure, and indeed has been the primary methodological paradigm in the investigation of attentional bias (Wells & Matthews, 1996), use of the visual-probe task has substantially increased over the last decade. Developed by MacLeod, Matthews, and Tata (1986), the visual-probe task is a computerised paradigm recording participant response times to a series of visually presented stimuli. As shown in Figure 3.1, following an initial fixation point, each trial simultaneously presents two forms of stimuli (traditionally words), in spatially distinct locations, on a computer monitor for a pre-determined length of time (typically 500ms). Following this presentation time, both stimuli are removed, with a visual probe (e.g. a dot) appearing in the same spatial location as one of the two previously presented stimuli. Participants are required to indicate, either via keyboard or response-box, the location of this probe as quickly as possible. Averaged response times to specific stimuli categories are calculated from the visual-probe task, providing an indication of whether certain participants show a particular response bias to trials containing stimuli associated with their emotional concerns.

Created as an alternative to the emotional Stroop task, the visual-probe task is argued to possess a number of important advantages over the aforementioned paradigm. Firstly, as the visual-probe task does not rely on interference effects, strategic override is likely to be less problematic than with the emotional Stroop task (Mogg and Bradley, 1998). Secondly, while participants may also choose to consciously monitor certain stimuli, the presentation times of stimuli are fully controlled by the researcher. This stands in contrast to the emotional Stroop task, where participant response partly determines the overall presentation time. Considering this, it can be argued that the issue of distinguishing between voluntary and involuntary attention is less problematic with the visual-probe task. As discussed in Chapter 2, humans are capable of both rapidly shifting their attention between current activities and other information (automatic attentional orientation), and sustaining attention upon current activities despite concurrent events and information

(elaborative attentional maintenance) (Allport, 1989). Within the visual-probe task, stimuli have often been presented for 500ms, with attentional bias at this stage considered to reflect an initial orienting of visual attention (Bradley, Mogg & Miller, 2000; Mogg, Miller, & Bradley, 2000b; Gamble & Rapee, 2009). Such attentional processes reflect a hypervigilance for threat, whereby the individual scans the environment for potential sources of perceived danger (Beck et al., 1985). Alternatively, biases at a longer presentation times (e.g. 1250ms) are more likely to reflect biases in maintained attention, allowing opportunity for multiple shifts of attention (Mogg & Bradley, 1998; Mogg et al., 2000b). Thus, the distinction between these two stages is of importance, as biases are likely to arise due to different attentional mechanisms.

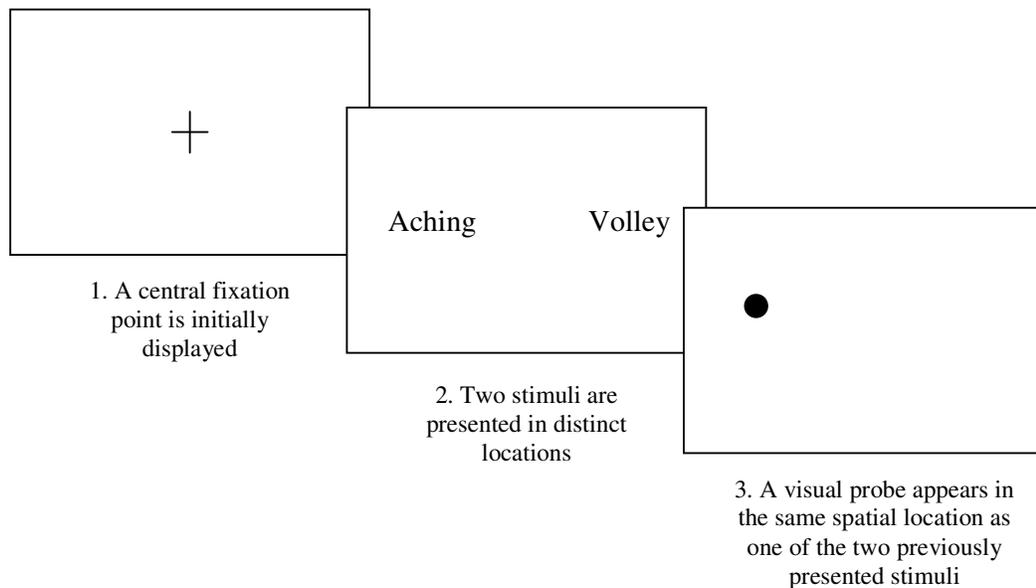


Figure 3.1. Graphical representation of the three main stages in visual-probe task trials.

It is important to note that variations in visual-probe methodology have been evident, with two common versions in existence. Within the probe-position version, participants are simply required to state the location of the probe (i.e. upper or lower). The probe-classification version, alternatively, requires participants to identify between two possible probes (i.e. the letters P and Q). While it has been argued that the latter encourages a more equal monitoring of both stimulus locations, it is also likely to be more difficult for participants. As there is direct stimulus-mapping with the former (i.e. the lower button for lower probes), the probe-position version is simpler to perform, and is therefore more appropriate for clinical populations (Mogg & Bradley, 1999). A consideration of methodological variations such as these is important when considering research that has adopted the visual-probe task in chronic pain patients.

#### *Attentional Biases towards Pain-Related Information in Pain-Free Individuals*

In addition to investigations looking at attentional biases via the visual probe task in chronic pain samples (this body of literature is reviewed below), research has also investigated whether pain-free, healthy samples demonstrate biased attention towards pain-related information. Keogh, Ellery, Hunt and Hannent (2001) have argued that such biases may not arise from the experience of chronic pain alone, but may instead reflect an underlying vulnerability, predisposing the individual to react with greater negativity when physical pain is experienced. Thus, the experience of chronic pain may not be necessary for biases to be observed. Recruiting 74 pain-free participants, Keogh, Ellery, et al. found those with high fear of pain to show significantly greater bias towards pain-related word stimuli than those with medium and low fear of pain (both  $p < .05$ ). Supporting this, Keogh, Dillon, Georgiou and Hunt (2001) found individuals with high anxiety sensitivity ( $n = 24$ ) to show a selective bias towards physical threat words, whilst those with low anxiety sensitivity ( $n = 27$ ) orientated away from such stimuli ( $p < .05$ ). These studies suggest psychological variables to be important in determining whether a pain-free individual is likely to demonstrate bias towards pain-related information.

Boston and Sharpe (2005) have also provided evidence that threat expectancy may be linked to attentional bias. One-hundred pain-free students were recruited, who received either threatening or non-threatening (reassuring) information concerning an upcoming cold-pressor task. Prior to this task, participants completed a visual-probe task. The results from this experiment found a significant interaction

between pain word type and threat condition ( $p = .008$ ). Specifically, individuals receiving threatening information demonstrated greater bias towards affective pain words, while those receiving non-threatening information showed increased bias towards sensory-pain words. These results suggest that interpretation of the different dimensions of pain may be an important factor in attentional bias. As discussed in Chapter 2, interpretation of pain is an important consideration in fear-avoidance models of chronic pain (Vlaeyen and Linton, 2000).

In contrast to the above findings, other investigations have provided contradictory evidence. Recruiting 100 pain-free students, Keogh and Cochrane (2002) found no evidence for attentional bias towards sensory and affective pain words in low, medium or high anxiety sensitivity groups. Arguing for the importance of investigating both conscious and preconscious attention, Keogh, Thompson and Hannent (2003) implemented both masked and unmasked stimuli in the visual-probe task, designed to measure conscious and preconscious attention respectively ( $N = 81$ ). The results from neither version found evidence for selective attentional bias towards pain-related information, although participants with low fear of pain were found to orientate away from pain-related stimuli in the unmasked condition ( $p < .05$ ). Roelofs, Peters, van der Zijden, Thielen and Vlaeyen (2003) reported the results of two investigations investigating biases in individuals with high and low fear of pain. Recruiting 90 female participants, the first experiment failed to find evidence for attentional bias towards pain-related words. Exploring the importance of presentation time, the second experiment ( $N = 120$ ) utilised the same paradigm but with 500, 740 and 1000ms stimuli presentation durations. Once again, no significant biases were found at any of these three durations.

To date, a number of studies have investigated whether healthy, pain-free individuals demonstrate biased attention towards pain-related information, although results are mixed. While there is some evidence to suggest that individuals with high fear of pain (Keogh, Ellery, et al. 2001) and anxiety sensitivity (Keogh, Dillon, et al, 2001) bias their attention towards pain-related information, not all studies have supported these findings (Keogh & Cochrane, 2002; Roelofs et al., 2003). Due to this inconsistency, further research is needed in this area before any firm conclusions can be drawn regarding the importance of individual difference variables in this field of research. Additionally, it is especially noteworthy that in all investigations cited above, healthy samples comprised of university students only, limiting the ability to generalise such findings to other populations. In all studies, the mean age of students

was relatively young (i.e. late teens to mid twenties). Age, however, has been associated with important changes in pain perception (e.g. Lautenbacher, Kunz, Strate, Nielsen & Arendt-Nielsen, 2005), and therefore bias towards pain-related information could vary with this factor. The ability to generalise the results from student samples to other populations is therefore limited, once again highlighting the need for further research.

#### *Attentional Biases towards Pain-Related Information in Chronic Pain Patients*

Visual-probe research investigating biases in chronic pain samples has increased over the past decade, although from an initial examination of the literature it is apparent that mixed results have been found. Overall, these results are not wholly supportive of theoretical models of pain which posit that such biases should exist (e.g. Pincus & Morley, 2001). However, many methodological limitations are apparent in studies adopting the visual-probe task (discussed below), warranting further investigation into this area. In addition, as a number of studies have found non-significant trends for bias or reported ambiguous findings, a quantitative synthesis and meta-analysis of these results may provide a clearer understanding of the available evidence. A meta-analysis is especially appropriate given the relatively small sample sizes notable in many former investigations, which may be unsuitable to detect smaller effect sizes. Indeed, one advantage of meta-analysis is the ability to detect small or moderate effect sizes through the combination of results (Ioannidis & Lau, 1999; Lipsey & Wilson, 2001). To date, however, no published meta-analysis of visual-probe tasks exists. While Pincus and Morley (2001) provided calculated effects sizes for two visual-probe studies, no meta-analytic procedure was performed. Considering this, the purpose of the current study was to conduct a systematic review and meta-analysis of former investigations utilising the visual-probe task to explore bias in chronic pain patients in comparison to healthy controls. As the majority of studies have investigated initial orienting of attention towards pain-related information, attentional biases at this stage were only considered in the current meta-analysis.

#### *Study Objective and Hypothesis*

The primary objective of this review was to assess whether individuals with chronic pain demonstrate attentional biases towards pain-related information, relative to healthy, pain-free controls. Based upon theoretical models of pain and attention, it

is hypothesised that the results of the meta-analysis will find support for such biases in chronic pain patients.

### 3.3. Scope and Methodology of Review

#### *Search Strategy*

Studies included in this review were identified through a computerised search of Medline, PsycInfo, CINAHL and Cochrane Library databases. Initial search terms included *attention\**, *bias\**, *probe*, *detection* and *\*vigilance* intersected with the term *pain*. Following this initial search, the key words of all obtained articles were evaluated for a secondary search of the same databases. This secondary search included the key words *headache\**, *arthritis* and *fibromyalgia*, which were intersected with the terms *pain* and *attention\**. All searches were made between February 1986 (when the visual-probe task was first used) and July 2009. An examination of the reference lists from all obtained articles was also conducted, along with a search of the above databases with the names of relevant researchers in the field. In order to try and overcome publication bias, relevant researchers were also contacted to request any unpublished or *in press* studies which may be eligible for this review.

#### *Inclusion Criteria*

In order to be eligible for inclusion in the meta-analysis, each study was required to meet the following four criteria (the same criteria, except 4 and 5, were adopted for the systematic review that precedes the meta-analysis):

1. Available in English language until July 2009.
2. Used a version of the visual-probe task (i.e. probe-classification version or probe-position version) with stimuli related to the sensory and/or affective dimensions of pain.
3. Included a sample of adults ( $\geq 18$  years old) with chronic pain, with chronic pain defined as pain that had lasted for a minimum duration of 3 months, and a sample of healthy, pain-free control participants.

4. Explored bias in relation to initial orienting of attention.
5. Provided independent data pertaining to, or enabling the calculation of, effect sizes and standard deviations of attentional bias indices<sup>1</sup>.

### *Search Results*

The electronic search identified 691 potentially relevant citations with initial search terms, along with a further 123 citations from secondary search terms. Of these 814 studies, 18 were obtained as potentially appropriate for inclusion in the review. A further 5 studies were identified through search of grey literature and from hand searching of appropriate journals and reference lists. Thus, 23 papers were considered for inclusion in the review, of which 5 were retained for the meta-analysis (Asmundson, Carleton, & Ekong, 2005; Asmundson, Wright, & Hadjistavropoulos, 2005; Lioffi, Schoth, Bradley, & Mogg, 2009; Khatibi, Dehghani, Sharpe, Asmundson, & Pouretamad, 2009; Roelofs, Peters, Fassaert, & Vlaeyen, 2005). Of the 17 papers excluded, 3 were uncontrolled, recruiting adult pain samples only (Dehghani, Sharpe, & Nicholas, 2003; 2004, Sharpe, Dear, & Schrieber, 2009), 2 recruited paediatric samples only (Boyer et al., 2006; Lipani & Vanderbilt, 2008), 6 recruited adult healthy samples only (Boston & Sharpe, 2005; Roelofs et al., 2003; Keogh et al., 2003; Keogh, Ellery, et al., 2001; Keogh, Dillon, et al., 2001; Keogh & Cochrane, 2002), 1 was not available in English (Van Damme & Crombez, 2006), 2 did not provide enough information to calculate attentional bias indices, and the data wasn't provided by the authors (Asmundson, Kuperos, & Norton, 1997; Moses, 1989), 2 did not utilise the dot-probe paradigm (von Bueren Jarchow, Radanov, & Jäncke, 2005; Weitlauf, 2003), 1 was a reanalysis of formerly published data already included (Asmundson & Hadjistavropoulos, 2007) and 1 unpublished dissertation was not provided by the author following request (Pincus, 1993).

### **3.4. Description of Studies**

To date, a total of eight known studies (in English language) have investigated whether individuals with chronic pain demonstrate attentional biases towards pain-related information compared to healthy controls. This includes seven

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<sup>1</sup> The attentional bias index is calculated via the formula  $((t_{upl} - t_{lp}) + (t_{pu} - t_{ulp}))/2$  where  $t$  = target stimulus,  $p$  = probe,  $u$  = upper,  $l$  = lower

published studies and one unpublished dissertation. While only five of these studies are included in the following meta-analysis (due to reasons stated above), for thoroughness all eight will be discussed and evaluated in this section. As a number of specific pain conditions have been investigated in this research (including mixed chronic musculoskeletal pain, chronic headache and chronic back pain), some limitations are apparent in reliably comparing the results of these studies. All investigations, however, recruited participants experiencing regular pain for at least 3 months. For purposes of clarity, studies featuring linguistic stimuli will be discussed first, followed by those which have adopted pictorial stimuli.

#### *Controlled Investigations with Linguistic Stimuli*

Asmundson et al. (1997) reported the first published investigation to utilise the visual-probe task with chronic pain patients. Participants included 19 patients experiencing chronic pain attributable to musculoskeletal injury and 22 healthy controls. Both pain (including sensory and affective dimensions) and injury related words were implemented in the task, with the former taken from the McGill Pain Questionnaire-short form (MPQ-SF; Melzack, 1987), and the latter provided by clinicians specialising in chronic pain. All injury and pain related words were paired with neutral words, matched on both length and frequency of use in the English language. In addition, 140 neutral-neutral word pairs were also included as filler material. During the visual-probe task, word-pairs were presented vertically in the centre of a computer monitor for 500ms. Following this, a dot-probe appeared after 25ms in either the upper or lower location on 28% of trials (including all experimental trials with pain and injury words, and a subset of neutral-neutral trials). Participants were instructed to press the spacebar as soon as they saw the probe. The results of this investigation failed to find evidence for different patterns of attentional performance between chronic pain and healthy control participants to either pain or injury words. Further analysis, however, revealed a significant *target position x probe position* interaction for patients with low fear of pain ( $p < .001$ ), suggesting such patients to shift attention away from pain-related words.

The results of this preliminary investigation did not find evidence for a general attentional bias across chronic pain patients. Instead, evidence was found to suggest that individuals with chronic pain may display different attentional patterns based upon levels of fear of pain. A number of limitations, however, should be noted. Firstly, as both sensory and affective descriptors of pain were combined into a single

stimulus condition, no information was provided on the respective influence of each. As patterns of bias may differ between these two different types of stimuli, combination without prior investigation may be inappropriate. Secondly, the methodology adopted did not encourage a naturalistic pattern of attention, as participants were required to read aloud the top word in each trial. It is therefore possible that participants were forced to override their initial eye-movement preference in order to meet these task demands, possibly reducing or eliminating any bias they may have otherwise demonstrated. Finally, while all experimental trials were followed by probes, only 11.4% of neutral-neutral trials were. Participants may have become aware of this fact, and thus been more vigilant during the former than the latter. The use of a single response button (i.e. the spacebar) compounds this problem, as participants may have been encouraged to respond on experimental trials regardless of whether they viewed the probe or not.

Since this initial investigation, Asmundson and colleagues have conducted a number of further investigations in this area. Asmundson, Carleton et al. (2005) recruited 30 patients with chronic headache, and 19 healthy controls. While a similar methodology to Asmundson et al. (1997) was utilised, a number of important differences are notable. Firstly, the recruitment of individuals with chronic headache can be considered a more defined and specific sample, as opposed to individuals with chronic pain stemming from musculoskeletal injury. Secondly, this investigation employed separate sensory and affective pain words (in addition to 160 neutral-neutral filler pairs). Finally, an investigation of congruency and incongruency effects<sup>2</sup> was performed, based on the assumption that the former allows for an investigation of attentional engagement with threatening stimuli, while the latter allows for an investigation of attentional disengagement (Asmundson and Hadjistavropoulos, 2007).

Despite methodological improvements, the results of this investigation failed to find any significant differences in performance between the chronic headache and control groups with the sensory or affective pain words. Such non-significant results were reported for all three indices of attentional bias (i.e. the bias, incongruency and congruency indices). Independent of groups (and with an alpha adjusted to  $p < .01$  for multiple correlations) however, it should be noted that anxiety sensitivity (measured

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<sup>2</sup> The congruency index was calculated via the formula  $(t_{pu} + t_{pl})/2$ , and the incongruency index via the formula  $(t_{pl} + t_{pu})/2$ . Here,  $t$  = target word,  $p$  = probe,  $u$  = upper,  $l$  = lower

via the Anxiety Sensitivity Index) was positively correlated with the sensory pain bias index ( $p < .01$ ). Thus, regardless of chronic pain status, participants with high anxiety sensitivity demonstrated bias towards sensory pain descriptors, once again suggesting the investigation of individual difference variables to be an important consideration in this field of research. Similar limitations to Asmundson et al. (1997) are notable in this investigation, however, including participants reading the top word aloud on each trial, and the use of a single response key. Furthermore, while the implementation of separate affective and sensory pain stimuli categories is advantageous, it is noteworthy that a level of ambiguity exists. For example, the affective words *exhausting*, *tiring* and *sickening* have strong sensory connotations. It is also important to note that investigation of congruency and incongruency effects (via their respective indices) may be somewhat redundant, as these two effects are not mutually exclusive from either each other, or the bias index.

Asmundson, Wright et al. (2005) investigated attentional bias in 36 patients with chronic musculoskeletal pain, along with 29 healthy controls. The same affective, sensory, health catastrophe and neutral words were utilised in both a visual-probe task and a computerised emotional Stroop task, enabling an investigation of differences between these respective paradigms (the emotional Stroop results are discussed in Chapter 7). Overall, little evidence was found to support the notion that chronic pain patients and healthy controls differ in their attention towards pain related information. However, on the visual-probe task, a significant main effect of clinical status was found for the incongruency bias index<sup>3</sup> ( $p < .05$ ), suggesting that those with chronic pain to display greater difficulty disengaging from threat than controls, regardless of word type. Correlational analysis revealed no significant correlations between any of the attentional measures and individual difference variables explored.

While the results of Asmundson, Wright et al. (2005) failed to find evidence for attentional bias in chronic pain towards specific pain stimuli, a later reanalysis provided support for the importance of fear of pain. Specifically, Asmundson and Hadjistavropoulos (2007) re-analysed the visual-probe data from their former investigation, separating participants into low, medium and high fear of pain categories based upon a number of differing conceptualisations of this variable. The

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<sup>3</sup> The congruency index was calculated via the formula  $((t_{pu} + t_{pl})/2) - ((n_{pu} + n_{pl} + n_{lu} + n_{lp})/4)$ , and the incongruency index via the formula  $((t_{pl} + t_{pu})/2) - ((n_{pu} + n_{pl} + n_{lu} + n_{lp})/4)$ . Here,  $t$  = target word,  $n$  = neutral target word (i.e. in neutral/neutral trials)  $p$  = probe,  $u$  = upper,  $l$  = lower

results showed no theoretically significant interactions from a re-analysis with raw visual-probe latency data. When categorised using cluster analysis, a trend main effect for fear of pain was found ( $p = .06$ ). Further investigation revealed evidence for vigilance towards all threat stimuli in participants with high fear of pain, all of whom were patients experiencing chronic pain. These results suggest that the presence of chronic pain may interact with psychological variables, such as fear of pain. It is therefore possible that not all chronic pain patients will demonstrate attentional bias, but only those who also display high levels of fear of pain. The researchers note, however, the importance of determining whether fear of pain is best considered a categorical or continuous variable, as different causes may be attributable in each case, a factor which has important implications for treatment.

Overall, research conducted by Asmundson and colleagues have provided little support for the notion that individuals with chronic pain display attentional biases towards relevant pain-related information. All studies, however, adopted very similar methodologies, and therefore a number of limitations can be highlighted throughout. Firstly, as discussed, all studies required participants to read the top word of each pair aloud, thus perhaps overriding any tendencies to bias initial attention towards specific words. Secondly, a single stimulus presentation time of 500ms was adopted in all investigations which, in combination with the first limitation, is problematic for a number of reasons. Specifically, evidence exists to support the notion that biases at 500ms reflect biases in initial orienting of attention; that is, the first saccadic eye movement (Bradley, Mogg & Miller, 2000). It is therefore contradictory to present task demands requiring participants to allocate their initial eye-movement towards a specific location. Furthermore, reading the top word aloud (which requires both eye-movements and production of verbal response) is likely to consume most of the 500ms presentation time, leaving little to no time for overt viewing and processing of the bottom word. Both issues support the argument that the methodology adopted by Asmundson and colleagues was not ideally suited to detect attentional bias.

Moses (unpublished thesis, 1989) investigated attentional bias in 17 patients with chronic pain. Instead of utilising a healthy control group, 17 individuals with non-painful chronic illness (maturity-onset diabetes) were recruited as a comparison group. The visual-probe task featured pain-words primarily related to the affective dimension of pain (e.g. *burden*, *debilitated*) although also included injury-related words (e.g. *paralysed*, *maimed*). Importantly, however, it was noted that sensory

descriptors of pain were specifically not included within this stimuli, as it was noted that such descriptors may not adequately convey pain states. In addition, general affect words were also included as a separate category, which were not specific to pain. All stimuli were presented for 500ms. Results from this investigation found no significant difference between the two groups in their responses to either pain or affect words. A second experiment, conducted in combination with a pain management programme, utilised the same visual-probe task both pre- and post-treatment, with data available from 13 chronic pain patients. Once again, however, no significant evidence of attentional bias was found at either time. Overall mean latencies did significantly decrease from pre- to post-treatment ( $p < .01$ ), however, which is suggested may have resulted from practice effects.

The unpublished experiments of Moses were conducted circa 1989, and therefore chronologically are the first known studies to have used the visual-probe task in this area of research. A number of methodological limitations are present (including the reading of the top word), although particular attention should be given to the pain stimuli utilised. Judges were asked to rate how threatening a series of pain-related words would be should they be experiencing chronic pain, with the final stimuli group taking from these ratings. The resulting stimuli, however, were a mixture of affective-pain and injury-related words that are unlikely to have been wholly relevant for the chronic pain sample recruited (e.g. *cancer, paralysed, wheelchair*). Furthermore, a number of neutral words used within matched pairs were themselves quite emotive (e.g. *brainwashing, intoxicating, convalescing*). Despite these limitations, the inclusion of a chronic illness comparison group without pain in the first experiment was advantageous, allowing for an investigation as to whether chronic illness alone is linked to bias, or whether chronic pain itself is necessary. As both groups showed similar response latencies, no significant between-group differences were found however. The inclusion of a healthy control group would have improved this investigation, as it is possible both groups would have shown a bias compared to individuals with no chronic disorders.

Attempting to overcome the noted limitations associated with past research, Lioffi, Schoth, Bradley, and Mogg (2009) recently conducted an investigation utilising a sample of 15 participants suffering from chronic headaches and 18 pain-free controls. Sixteen sensory and 16 affective pain words were utilised in a visual-probe task, derived from the International Classification of Headache Disorders (ICHD-II; Headache classification subcommittee of the international headache

society, 2004) and the Chronic Pain Experience Instrument – Headache Version (CPEI; Davis & Grassley, 2005) respectively. Such stimuli were argued to provide pain descriptors relevant to the sample investigated. Additionally, a conscious effort was made to provide discrete sensory and affective categories, eliminating ambiguous stimuli that could be considered appropriate for either. Perhaps the most important methodological manipulation to the visual-probe task, however, was the adoption of two presentation times, including the traditional 500ms and the addition of a longer 1250ms. These two presentation times allowed for an investigation of bias in both initial orienting and maintained attention respectively. While the results from this investigation found no significant difference between chronic headache and pain-free participant performance with stimuli shown in the 500ms condition, significant differences were found in the 1250ms condition. Specifically, participants with chronic headache demonstrated significantly greater bias towards headache-related words than healthy controls at 1250ms ( $p = .05$ ), indicating an attentional bias towards headache-related stimuli. As no significant *group x word type* interaction was found, it is suggestive that both sensory and affective descriptors of pain were relevant to the chronic headache group, both capturing attention. However, it is also possible that, due to the relatively small sample size, a significant interaction was not found due to lack of statistical power.

#### *Controlled Investigations with Pictorial Stimuli*

To date only two published studies have investigated bias towards pictorial stimuli in chronic pain. Considering the first, Roelofs, Peters, Fassaert and Vlaeyen (2005) recruited 49 patients with chronic low back pain and 44 healthy controls. Participants completed two versions of the visual-probe task, including a linguistic version with sensory pain, affective pain, injury, movement, social threat and neutral words, and a pictorial version containing images from the Photograph series of Daily Activities (PHODA [Kugler, Wijn, Geilen, De Jong, & Vlaeyen, 1999]), with all stimuli presented for 500ms. Considering the latter, participants were shown a series of PHODA images, and were required to evaluate each image in regards to how threatening the activity depicted would be for their back. A total of ten images were utilised, including the five images with the highest threat ratings and the five images with the lowest threat ratings. Neutral filler material was derived from the International Affective Picture System (Lang, Öhman, & Vaitl, 1988). The results from this important investigation showed no significant differences between the two

participant groups in relation to visual-probe performance with words. Considering pictorial stimuli, a significant incongruency effect<sup>4</sup> ( $p = .006$ ) was found, indicating all participants to display a difficulty in disengaging from threatening images. Furthermore, this difficulty was found to be significantly greater in patients than healthy controls.

While the above therefore provides some evidence that individuals with chronic pain have greater difficulty disengaging from pain-related images than healthy controls, a number of limitations can be highlighted. Firstly, although the images used in the pictorial version of the visual-probe task were idiosyncratically chosen, the words used in the linguistic version were not. Thus, any significant effects found may be at least partly attributable to recognition of previously viewed stimuli. This difference in stimuli selection procedure also makes comparison between the two tasks more difficult. Secondly, the PHODA is an instrument used to determine the subjectively rated harmfulness of a range of daily activities (e.g. household chores, physical exercise) combined with different movement prototypes (e.g. lifting, bending). This stimuli set therefore does not convey pain-related information alone, but also threat to physical integrity and injury-threat information. The specificity of bias therefore cannot be determined from this investigation, as difficulty disengaging from the PHODA images may have arisen for a number of different reasons. Finally, due to technical errors with the visual-probe programme, a large amount of data was unusable, resulting 31 patients completing the visual-probe with words, and 49 patients completing the visual-probe with images. Despite these limitations, Roelofs et al. (2005) were the first to explore alternative stimuli possibilities in relation to attentional biases in chronic pain.

Recently, Khatibi et al. (2009) provided a second investigation implementing pictorial stimuli, recruiting 170 patients with chronic musculoskeletal pain and 40 healthy controls. Pictorial stimuli consisted of painful and happy facial expressions, which were paired with neutral expressions of the same model. During the visual-probe task (probe-classification version), image pairs were presented for 300ms, followed by a central fixation point for 100ms. Finally, an arrow ( $\leftarrow$  or  $\rightarrow$ ) was presented in either the upper or lower location, with the task of the participant being to indicate the direction this arrow was facing (i.e. left or right) via keyboard. The

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<sup>4</sup> The congruency index was calculated via the formula  $(t_{pu} + t_{pl})/2$ , and the incongruency index via the formula  $(t_{pl} + t_{pu})/2$ . An index for neutral control trials was calculated via  $(n_{pu} + n_{pl} + n_{lu} + n_{lp})/4$ . Here,  $t$  = target word,  $n$  = neutral word  $p$  = probe,  $u$  = upper,  $l$  = lower

results revealed both groups to bias away from happy facial expressions (both  $p < .001$ ). However, while the chronic pain group demonstrated a level of avoidance of painful facial expressions, this was only significant within the healthy control group ( $p < .001$ ). Thus, overall no evidence was found to support the notion that those with chronic pain bias towards pain-related stimuli. Further to this analysis, participants with chronic pain were split into low and high fear of injury groups. Both groups displayed significant biases away from happy facial expressions (both  $p < .001$ ). Considering the pain expressions, those with low fear demonstrated a significant bias away ( $p < .001$ ), whilst those with high fear showed a significant bias towards such stimuli ( $p < .001$ ).

The results of Khatibi et al. (2009) suggest fear of movement to be an important factor in determining whether individuals with chronic pain display attentional bias towards relevant pain-related information. Indeed, in this instance, a failure to consider this variable revealed no evidence of attentional bias with painful expressions. The utilisation of facial expressions can be considered advantageous when compared to the PHODA stimuli employed by Roelofs et al. (2005), as less ambiguity may be present. However, Khatibi et al. asked professional actors/actresses to assess the intensity of pain and happiness in their facial stimuli, who may be better judges of such expressions than individuals from the general population (i.e. able to detect subtle emotions with greater accuracy). Additionally, it is possible that facial expressions of pain may have been interpreted by participants as conveying other emotions (e.g. anger or fear), although no investigation was conducted into this (at least this was not reported). This is an important consideration, however, as any evidence of bias found may have stemmed from a perception of information other than pain. Related to this, it is unknown whether the researchers adopted any standardised method of categorising their facial stimuli (e.g. the Facial Action Coding System; Ekman & Friesen, 1978). A final limitation of this investigation was the presence of a fixation point displayed between the images and subsequent probes. However, as this point was only display for 100ms, it may have not been long enough to interrupt any biases participants held. Once again, however, the purpose of this fixation point was not discussed.

### *Methodological Decisions*

A number of methodological decisions were made prior to the meta-analysis procedure:

1. Only bias data pertaining to the sensory and affective dimensions of pain were used. In instances when both were used, their respective indices and SDs were averaged into single scores. Bias data towards other forms of threat (i.e. social threat, injury, movement, and health catastrophe stimuli) were not included.
2. Only data pertaining to initial orienting of attention were included. While the majority of studies employ a 500ms presentation time, those utilising 300ms (i.e. Khatibi et al., 2009) were also included. This decision is based upon the notion that this presentation time also measures initial orienting, as supported by saccadic eye-movement data in the visual-probe task (i.e. Mogg et al., 2000b) (it has also been suggested that this 200ms difference should not substantially effect bias results [Keogh, Thompson, & Hannent, 2003]). In instances where attentional maintenance was investigated (i.e. Lioffi et al., 2009), this data was not included.
3. In instances where bias indices and/or SDs had to be calculated from raw data, the following formula was used on response time data:  $((t_{upl} - t_{lp}) + (t_{pu} - t_{pu}))/2$  (t = target, p = probe, u = upper, l = lower).

### *Statistical Analysis*

Study characteristics for each investigation included in this meta-analysis are presented in Table 3.1. For this meta-analysis, attentional bias scores were utilised, which were either taken from their respective articles (Asmundson, Carleton et al, 2005; Asmundson, Wright et al, 2005; Roelofs et al, 2005; Lioffi et al, 2009), or were calculated from data provided by the authors (Khatibi et al, 2009). As the majority of studies in this field of research only report attentional bias scores, the decision was made to use these instead of mean response times. If these scores “average to zero across various independent studies, this indicates that any significant effects found for individual studies are unlikely to have been accurate”

(Frewen, Dozois, Joanisse, & Neufeld, 2008. p311). A random-effects model was implemented, which assumes that individual studies vary in their average effect sizes, and therefore heterogeneity is to be expected (Field, 2003). Although random-effects models have less statistical power than fixed effects models, results may be generalised to similar studies not included in the actual analysis (Rosenthal, 1995). A number of statisticians favour the use of random-effects models over fixed effects models (e.g. Rosenthal & DiMatteo, 2001; Field, 2003). Within this analysis, the standardized mean difference (Hedge's adjusted *g*) was used. Review Manager 5.0 (2008) was used for all analyses.

Table 3.1.

*Characteristics of the five studies included in the meta-analysis investigating attentional bias via the visual-probe task*

Study	Country	Visual-probe version	Stimuli type	Type of pain	Mean duration of pain	Sample size (pain/control)
Asmundson, Carleton et al. (2005)	Canada	Probe-position (500ms)	Words (sensory & affective)	Migraine headache	17.7 years	30/19
Asmundson, Wright et al. (2005)	Canada	Probe-position (500ms)	Words (sensory & affective)	Musculoskeletal	36.74 months	36/29
Khatibi et al. (2009)	Iran	Probe-classification (300ms)	Images (expressions of pain)	Musculoskeletal	6.7 months	170/40
Lioffi et al. (2009)	UK	Probe-position (500ms)	Words (sensory & affective)	Headache	10 years	15/18
Roelofs et al. (2005)	The Netherlands	Probe-position (500ms)	Words (sensory & affective)	Lower back pain	12 years	49/44

Two researchers (D. Schoth & C. Lioffi) independently verified attentional bias data to be used in the meta-analysis. These same authors also performed a quality assessment for each of the five studies included in the meta-analysis (Table 3.2), based upon information contained in the published reports. Criteria (Appendix A) used were based upon those specified by Roelofs et al. (2002) in their meta-analysis of emotional Stroop tasks investigating attentional bias in chronic pain. Any disagreements were resolved by discussion. The two raters had 97.5% agreement, with discrepancies resolved by discussion and re-reading of the articles. With the exception of Roelofs et al. (2005), all studies were considered to have high levels of methodological quality based upon the adopted criteria.

Table 3.2

*Ratings of methodological quality for each study included in the meta-analysis*

	Asmundson, Carleton et al. (2005)	Asmundson, Wright et al. (2005)	Roelofs et al. (2005)	Lioffi et al. (2009)	Khatibi et al. (2009)
Inclusion criteria	0	1	0	1	1
Exclusion criteria	0	1	0	1	1
Types of patients	1	1	1	1	1
Matching controls	0	1	0	0	0
Matching stimuli	1	1	1	1	1
Environment	1	0	0	1	1
Depression	1	1	0	1	1
Anxiety	1	1	0	1	1
Pain-related fear	1	1	1	1	1
Statistical analysis	1	1	1	1	1
<b>Total</b>	<b>7</b>	<b>9</b>	<b>4</b>	<b>9</b>	<b>9</b>

### 3.5. Results

#### *Meta-Analysis Results*

The results from the 5 studies included in the meta-analysis are presented in Table 3.3, while Figure 3.2 presents the effects sizes and confidence intervals in graphical form. Across all studies, the mean between-groups effect size was .40 (95% CI, 0.04 - 0.76). The combined effect size was significant ( $p = .03$ ). Thus, patients with chronic pain demonstrated significantly greater bias towards pain-related information compared to healthy, pain free controls. Due to the small number of studies included in this analysis, statistical examination of publication bias presents difficulties. However, evaluating the studies' individual results, 1 study (Khatibi et al., 2009) found significant differences between chronic pain and healthy control groups in patterns of attentional bias in initial orienting, whereas 4 studies (Roelofs et al., 2005; Asmundson, Wright et al., 2005; Asmundson, Carleton et al., 2005; Lioffi et al., 2009) did not.

Investigation into study heterogeneity revealed significant heterogeneity, as measured by Cochrane's Q ( $\chi^2 = 11.12, p = .03$ ), and the  $I^2$  statistic,  $I^2 = 64\%$ . In order to investigate potential causes of heterogeneity, the meta-analysis was performed again with the exclusion of Khatibi et al. (2009). This decision was made as Khatibi et al.'s study differed the most methodologically from the other four investigations, utilising a) a probe-classification version of the visual-probe task, b) pictorial stimuli, c) patients with the shortest mean pain duration, d) a 300ms stimuli presentation time, and e) highly unequal sample sizes (see Table 1 for details). In contrast, all other studies utilised linguistic stimuli presented for 500ms in a probe-location version of the visual-probe task. The results from this subsequent meta-analysis found a mean between-groups effect size of .25 (95% CI, 0.01 - 0.50). The combined effect size only found a trend for significance ( $p = .06$ ). Investigation into study heterogeneity with these remaining 4 studies revealed a non-significant Cochrane's Q ( $\chi^2 = 1.41, p = .70$ ), and a low  $I^2$  statistic,  $I^2 = 0\%$ .

Table 3.3.

Attention bias scores (SD), effect sizes, 95% confident intervals, and weightings for each study in the meta-analysis, ordered alphabetically

Study	Chronic pain ABS	Healthy control ABS	Std. Mean difference	95% CI	Weight
Asmundson, Carleton et al. (2005)	9.2 (67)	-4.6 (39.65)	0.23	-0.34, 0.81	17.7%
Asmundson, Wright et al. (2005)	5.05 (37.7)	2.65 (26.4)	0.07	-0.42, 0.56	20.2%
Khatibi et al. (2009)	-8.25 (67.24)	-65.93 (10.75)	0.95	0.59, 1.30	24.5%
Lioffi et al. (2009)	6.4 (22.85)	4.05 (19.8)	0.11	-0.58, 0.79	14.9%
Roelofs et al. (2005)	26.6 (39.4)	12 (25.9)	0.43	0.02, 0.84	22.7%

Note ABS= Attentional Bias Score

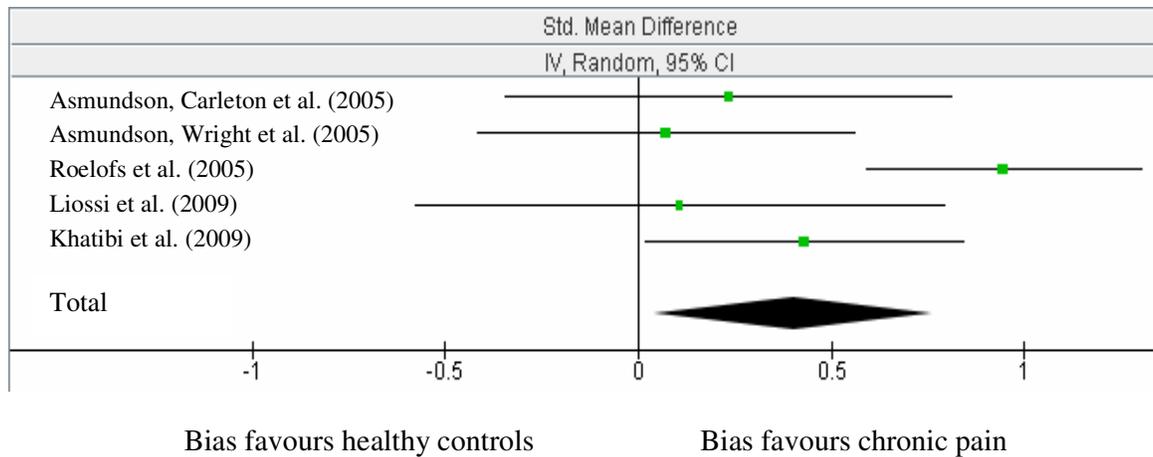


Figure 3.2. Forest plot of individual study effect sizes ordered alphabetically

### 3.6. Discussion

Theories of attention and pain predict individuals with chronic pain to display attentional bias towards pain-related information, although research supporting this notion has remained inconsistent. The aim of the present study was to systematically review research using the visual-probe task to investigate biases in chronic pain, and to meta-analyse the results of controlled studies exploring bias in initial orienting of attention. Providing partial support for the adopted hypothesis, results from this meta-analysis found individuals with chronic pain to display greater bias towards pain-related information compared to healthy controls. However, study characteristics were shown to be important, as the removal of the most methodologically different study (Khatibi et al., 2009) resulted in only trend evidence for greater bias in chronic pain patients in a sensitivity-analysis.

The visual-probe task is a paradigm commonly used to assess attentional bias. Research utilising this task to investigate bias in anxiety has found relatively consistent evidence to support the existence of such biases (Bar-Haim et al., 2007). As highlighted in the current systematic review, such consistency has not been found for biases in chronic pain. Indeed, of the eight controlled studies reviewed, only Lioffi et al. (2009) provided clear evidence that individuals with chronic pain display significantly greater bias *towards* pain-related information relative to healthy controls. Such evidence was only found during stages of maintained attention (i.e. presentation time of 1250ms). When considering initial orienting of attention (i.e. 300 - 500ms), none of the reviewed studies found clear evidence for significantly different patterns of bias between chronic pain and healthy control groups. Thus, from the systematic review, it appears attentional biases in chronic pain may arise voluntarily, perhaps due to rumination over stimuli meaning. The distinction between initial orienting and maintenance of attention is therefore an important one in this area of research, although it is somewhat surprising that only Lioffi et al. (2009) have to date investigated the latter attentional stage.

The pattern of findings highlighted in the systematic review contrasts to some degree with the results of the current meta-analysis, which did find evidence for different patterns of bias between chronic pain and healthy groups in initial orienting. However, as has been noted, one advantage of conducting meta-analyses is the ability to detect small or moderate effect sizes through the combination of results (Ioannidis & Lau, 1999; Lipsey & Wilson, 2001). In the current meta-analysis, the

effect size from all five studies was .40. As many of the individual studies included in this analysis recruited small to medium sample sizes, these studies may have lacked adequate statistical power to detect anything but large effect sizes. Despite this, it is notable that in four of the five studies included in the meta-analysis (Asmundson, Carleton et al., 2005; Asmundson, Wright et al., 2005; Roelofs et al., 2005; Lioffi et al., 2009), examination of mean attentional bias scores reveals stronger biases towards pain stimuli in the chronic pain groups than the healthy control groups. Thus, the current results suggest that biases are also found in initial orienting, whereby the attentional of chronic pain patients is automatically captured by pain-related information.

As the meta-analysis found evidence of significant study heterogeneity, a second sensitivity-analysis was conducted following the removal of one study (i.e., Khatibi et al., 2009). As justified, this study differed methodologically from the other four studies in a number of ways. Firstly, it was the only study to use pictorial stimuli presented for 300ms (although Roelofs et al. [2005] used images in one experiment, data from these were not included in the present analysis as they did not depict sensory or affective dimensions of pain), the only study to use a probe-classification version of the visual-probe task, recruited patients with relatively newly developed chronic pain (mean duration 6.7 months), and finally recruited very unequal sample sizes. With the removal of this study, heterogeneity decreased markedly, while the difference between chronic pain and healthy controls remained at trend level only. This pattern of results suggests that certain aspects of the methodology adopted by Khatibi et al. were particularly effective at eliciting differences between groups. One possibility is that pictorial stimuli are more likely to capture attention, possible due to higher levels of ecological validity (Kindt & Brosschot, 1997). However, as multiple differences are apparent between this investigation and the others, the importance of pictorial stimuli can only be speculated, with further research necessary. Such research is also necessary as Khatibi et al. only found chronic pain patients with high fear of pain to bias towards facial expressions in pain, while those with low fear demonstrated an avoidance of such stimuli. Questions therefore remain regarding the importance of both stimuli type and individual differences such as fear of pain.

A number of methodological limitations have been raised in former attentional bias research. Perhaps the biggest limitation, however, has been evident in the research of Asmundson and colleagues (Asmundson et al, 1997; Asmundson, Carleton et al., 2005; Asmundson, Wright et al., 2005). Specifically, the tasks

adopted in these studies required participants to read the top word of each pair aloud. This task requirement may have overridden any tendencies to bias towards specific words (e.g. if the pain word is in the lower location), and significantly reduced the ability of the task to detect biases. A second limitation has been the use of general pain stimuli that might not be wholly relevant for the chronic pain samples recruited. Of the studies included in the meta-analysis, a number (i.e. Asmundson, Wright et al., 2005; Khatibi et al., 2009) recruited patients with chronic musculoskeletal pain stemming from various body locations. If stimuli in such studies have less personal relevance, then evidence of attentional biases may not be particularly strong. Considering these limitations, it is possible that the visual-probe task has not been appropriately used in the majority of former investigations, reducing the chances of biases being found. Future research, including that on the current doctoral thesis, should therefore aim to improve the methodological quality of research in this area.

All studies included in the meta-analysis were independently assessed for methodological quality by two raters. Based upon the adopted criteria, the results of this assessment showed high levels of methodological quality for four of the five studies (Asmundson, Carleton et al., 2005; Asmundson, Wright et al., 2005; Liossi et al., 2009; Khatibi et al., 2009). Roelofs et al. (2005), however, was assessed with a lower level of quality. One of the main limitations of this study was the failure to consider levels of depression or anxiety in their sample, although both of which have been linked to attentional bias (e.g. Bar-Haim et al., 2007 – anxiety; Kellough, Beevers, Ellis & Wells, 2008 – depression). The results of the quality assessment should be interpreted with caution for two reasons however. Firstly, visual-probe criteria were not included in this assessment, although numerous limitations in the use of this paradigm have been raised. As many of these limitations remain to be empirically tested (e.g. no study has specifically tested whether reading the top-word aloud impedes bias), the decision was made to not include these criteria within the assessment. Should some of the proposed visual-probe limitations be incorrect, this would result in an unfair and inaccurate assessment of former investigations. Therefore, more general methodological criteria were adopted, which are more certain to affect study quality (e.g. appropriateness of statistical analysis). Following the testing of the speculated visual-probe limitations, a more accurate quality assessment may be performed. Secondly, as only information included in the articles was reviewed, this quality assessment may reflect quality of reporting as opposed to quality of study methodology. Due to article space limitations, authors may have

chosen to omit certain information from their final published reports. This may explain the lack of specified inclusion and exclusion criteria for both chronic pain patients and healthy controls in two studies (Asmundson, Carleton et al., 2005; Roelofs et al., 2005). Should this information exist (specifically both studies did not report criteria for healthy controls), reporting would have been of benefit, allowing readers to a) understand more fully the samples recruited, and b) more closely replicate these studies should they wish to do so.

The current study is the first known investigation to meta-analyse results from research using the visual-probe task in chronic pain populations. In contrast, Roelofs et al. (2002) reported a meta-analysis with results from the emotional Stroop task, finding chronic pain patients to selectively attend towards sensory and affective descriptors of pain. Reviewed in combination, the results from these meta-analyses suggest both visual-probe and emotional Stroop tasks to be useful paradigms for assessing attentional bias in chronic pain. However, much like research with the visual-probe task reviewed in the present study, research adopting the Stroop task has yet to consider a number of important variables, including the use of pictorial stimuli. It is also apparent that further research is needed to assess the importance of stimuli specificity via this paradigm. Considering this, future research is therefore needed with both paradigms to provide a more detailed account of attentional bias in chronic pain.

A number of limitations should be noted with the present meta-analysis. Firstly, this study was limited to biases towards pain-related information. While it has been concluded that chronic pain patients demonstrate greater biases towards information associated with pain, an alternative possibility is that such biases are shown towards negative stimuli in general. As the current study did not include an analysis of bias towards other forms of negative information, this alternative explanation cannot be ruled out. In defence of the methodology adopted, however, only one controlled study eligible for inclusion made use of non-pain related threatening stimuli (i.e. social threat by Roelofs et al, 2005), making any meta-analysis redundant. Regardless of this, further research is needed to address this important question, and shall be provided over the course of this thesis. A second potential limitation was the combination of sensory and affective dimensions of pain into a single pain category. As the majority of former studies have included these dimensions as separate categories, separate analyses may have been preferable. However, a limitation with many former studies has been a level of ambiguity

between these two categories (e.g. affective words *exhausting*, *tiring* and *sickening* have sensory connotations [Asmundson, Carleton et al. (2005)]). Additionally, the results of Lioffi et al. (2009) suggest both dimensions of pain to capture attention in individuals with chronic headache (during maintained attention). Thus, the combining of sensory and affective dimensions of pain is advantageous, which possibly reflects the experience of chronic pain to a greater extent than either dimension alone.

Related to the above, a further limitation may be the combining of studies using word stimuli and pictorial stimuli in the same meta-analysis, as these stimuli vary in a number of different ways. It has been noted that while words convey semantic threat, pictures convey both semantic and perceptual threat (Lees, Mogg, & Bradley, 2005). Pictorial stimuli are also likely to possess higher levels of ecological validity than single words (Kindt & Brosschot, 1997). The current study provides evidence for this, as removal of the only investigation to use pictorial stimuli (i.e. Khatibi et al., 2009) revealed a marked decrease in study heterogeneity, and only trend evidence for bias in chronic pain patients. However, as discussed above, this study differed in a number of other ways from the remaining investigations, and the precise reasons for these statistical variations remain unknown, warranting further research.

Comparing studies that have recruited patients from different chronic pain populations may also present some difficulties. Pain conditions are heterogeneous in many regards, including aetiological characteristics, pathophysiology, pain location, intensity, associated disability, and response to treatment. It is therefore possible that different pain groups may also display different patterns or strengths of attentional bias. However, as noted above, mean attentional bias scores for all but one study (i.e. Khatibi et al., 2009) revealed a preference for pain stimuli compared to neutral stimuli in individuals with chronic pain. Although not statistically significant in all cases, such evidence nevertheless supports theoretical models of attention and pain which predict bias towards pain-related information and cues in individuals with pain (e.g. Pincus & Morley, 2001). However, in order to investigate bias specificity, exploration of a single chronic pain condition is advantageous. In consideration of this, the remainder of this doctoral thesis shall focus upon individuals with chronic headache, exploring both the specificity and time-course of bias in such individuals compared to healthy controls.

The current study utilised the attentional bias index only. As discussed in the systematic review, some researchers have chosen to also calculate congruency and incongruent indices. It has been argued that in visual-probe research, both vigilance for threat and difficulty disengaging from threat may be responsible for any evidence of bias found (Koster, Crombez, Verschuere, & De Houwer, 2004). However, the calculation of congruency (corresponding to vigilance) and incongruency (corresponding to difficulty disengaging) indices do not provide mutually exclusive data, either from each other or the traditional bias index. To illustrate, an individual who demonstrates an attentional bias for pain-related information would show vigilance for such information (a congruency effect), responding faster to probes appearing in the same spatial location. Consequently, probes appearing in the opposite location would be responded to slower (an incongruency effect). Thus, regardless of whether the individual possess a difficulty disengaging from pain-related information, an incongruency effect has been found. Mogg, Holmes, Garner, and Bradley (2008) have also argued that an incongruency effect may not necessarily reflect a difficulty disengaging from threat, but alternatively a general slowing of response due to the presence of threat (i.e. responses to neutral/threat trials are slower than neutral/neutral trials regardless of attentional deployment). It is also important to note that methods of calculating congruency and incongruency indices has varied across studies, with some research utilising data from experimental trials only (i.e. Asmundson et al., 1997; Khatibi et al., 2009), and some from both experimental and control trials (i.e. Asmundson, Carleton et al., 2005; Roelofs et al., 2005; Asmundson, Wright et al., 2005). Comparison of results between these different calculation methods may therefore not be wholly reliable. In the latter instance, while control stimuli are considered to be neutral, this may not necessarily be true for all participants. Therefore evidence of bias based upon both experimental and control trial data could reflect a significant impact of either stimuli type (e.g. an individual may be especially avoidant of control stimuli, leading to an incorrect interpretation of bias towards pain stimuli). For these many reasons, congruency and incongruency indices were not included in the meta-analysis.

In conclusion, the results from this meta-analysis provide partial support for the theoretical notion (e.g. Pincus & Morley, 2001) that individuals with chronic pain demonstrate attentional biases towards pain-related information at stages of initial orienting of attention. While significant bias is found with all eligible studies, the sensitivity-analysis resulted in trend evidence only. This analysis therefore supports

the continuing investigation of biases in initial orienting of attention via the visual-probe task, although highlights the importance of fully exploring methodological parameters that may be responsible for the observed heterogeneity. One possibility for further investigation includes the use of pictorial stimuli, which to date has only been utilised in two studies (Roelofs et al., 2005; Khatibi et al., 2009). The current programme of research will therefore aim to provide information on sensitivity of such stimuli in chronic pain attentional bias. In addition to the meta-analysis, the systematic review has also raised avenues for further investigation. Firstly, it is notable that only one study to date has investigated maintained attention, providing evidence for bias at this attentional stage in individuals with chronic headache (Lioffi et al., 2009). Further research is needed into the time-course of attentional bias, as it is currently unclear whether biases in chronic pain are stronger during initial orienting or maintained attention. This question shall be addressed in the following three experiments, which investigate time-course of bias in chronic headache. Secondly, questions remain concerning the specificity of bias in chronic pain. As noted, the lack of statistical evidence for bias in some former investigations may be at least partly attributable to issues of stimuli relevance. The remainder of this thesis will therefore investigate specificity of bias, addressing whether biases are shown towards disorder-relevant stimuli only, or also towards more general depictions of pain. Furthermore, bias towards information representing threat to health, and non-pain related threat will also be examined, providing a detailed account of specificity of bias in chronic pain. Overall, the current study has addressed the main aim of this doctoral thesis, which is to establish whether attentional biases exist in individuals with chronic pain relative to healthy controls. Based upon the support provided, the empirical experiments in this doctoral thesis shall utilise both the visual-probe task and the emotional Stroop task to address remaining unanswered questions, including those concerning the time-course and specificity of attentional bias.

## **Chapter 4**

### **Experiment 1<sup>5</sup>: Attentional bias towards pictorial representations of pain in individuals with chronic headache**

#### **4.1. Summary**

This chapter presents the first experiment conducted on the PhD, which was an investigation into the time-course of attentional bias towards pictorial representations of headache pain. A total of 38 participants were recruited, including 17 meeting the diagnostic criteria for chronic headache and 21 pain-free, healthy controls. Stimuli presentation times of 500 and 1250ms were utilised, reflecting initial orienting and maintained attention respectively. The results showed the chronic headache group to demonstrate a significant attentional bias towards headache images, which was not significantly affected by presentation time. No significant correlations were found between attentional bias and any of the self-report measures utilised. The results add to a growing number of studies supporting the notion that individuals with chronic pain demonstrate biased attention towards information related to their pain.

#### **4.2. Introduction**

Theoretical models of attention and pain posit that individuals with chronic pain should demonstrate attentional biases towards information related to pain (e.g. Pincus & Morley, 2001). Within recent years, the visual-probe task (Macleod, Matthews & Tata, 1986) has been increasingly used to test this notion, although mixed evidence has been found. One possible explanation for these mixed findings includes the fact that relatively little methodological manipulation has been evident with this paradigm. Indeed, the majority of investigations have followed the same methodological formula, presenting linguistic stimuli for 500ms only (Asmundson, Kuperos & Norton, 1997; Dehghani, Sharpe & Nicholas, 2003; 2004; Asmundson,

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<sup>5</sup> Parts of this Chapter have been published as follows: Schoth, D. E. & Liossi, C. (2010). Attentional bias towards pictorial representations of pain in individuals with chronic headache. *The Clinical Journal of Pain*. 26 (3): 244 – 250.

Carlton & Ekong, 2005; Asmundson, Wright & Hadjistavopoulos, 2005; Sharpe, Dear & Schrieber, 2009). Of these investigations, three (Dehghani et al., 2003; 2004; Sharpe et al., 2009) have reported evidence of bias towards pain-related words, although all lacked the inclusion of a healthy control group (see Chapter 5 for a detailed discussion of these uncontrolled studies).

Arguing for the importance of investigating multiple stages of attention, Lioffi and colleagues (Lioffi, Schoth, Bradley & Mogg, 2009) found that, compared to healthy controls, individuals with chronic headache showed significantly greater bias towards headache-related words presented for 1250ms. In contrast, no significant difference was found for words presented at 500ms. Evidence of bias at 500ms is considered to reflect an initial orienting of attention towards threat (e.g. Bradley, Mogg & Miller, 2000), which itself is a characteristic of hypervigilance (Beck, Emery & Greenberg, 1985). In contrast, a longer exposure duration of 1250ms is more sensitive to processes involved in maintenance of attention, allowing greater opportunity for multiple shifts of attention between the stimulus pair items (Mogg & Bradley, 1998). As longer exposure times allow for excessive elaboration upon stimuli (Donaldson, Lam & Matthews, 2007), bias at 1250ms may reflect rumination over relevant emotional material. The results of Lioffi et al. therefore suggest that bias in chronic pain may only exist in maintained attention. However, a meta-analysis of former controlled studies (Chapter 3) found that, compared with healthy controls, individuals with chronic pain show bias towards pain-related information during initial orienting of attention. Furthermore, Boyer et al. (2006) report children with recurrent abdominal pain to show significant bias towards pain words presented subliminally for 20ms, but significant avoidance of such stimuli presented at 1250ms. The time-course of attentional bias in chronic pain is therefore unclear, with further research necessary to provide clarification.

In addition to manipulation of presentation time, exploration into alternative forms of stimuli is also important. Former research has relied almost exclusively upon word stimuli, and it is uncertain whether results obtained with words can be generalised to other forms of stimuli. For example, compared to words, pictures more closely resemble the objects they depict, and are likely to possess higher levels of ecological validity (Kindt & Brosschot, 1997). In addition, as chronic pain patients are likely to spend more time thinking about pain or speaking with others about it (including numerous health care professionals, friends, and family), pain words are likely to become primed due to their frequency of use. The effects observed in

previous studies with pain-related words may therefore reflect high familiarity and subjective frequency of use, rather than pain-related attentional bias per se. A further limitation is that linguistic stimuli can convey multiple meanings, including meanings not directly associated with pain. For example, sensory descriptors used by both Dehghani et al. (2003; 2004) and Sharpe et al. (2009) included *shooting*, which can be associated with gun crime, and *burning*, which can be associated with fire. Due to these factors, utilisation of pictorial stimuli may be beneficial in this field of research. To date, however, only two former investigations have made use of such stimuli. Roelofs and colleagues (Roelofs, Peters, Fassaert & Vlaeyen, 2005) employed images of various daily activities varying in their threat value to back pain. The results showed significant incongruency effects for both patients and healthy controls to stimuli at 500ms, which was significantly greater in the former than the latter group. More recently, Khatibi, Dehghani, Sharpe, Asmundson and Pouretemad (2009) found that, when split into low and high fear of injury groups, chronic pain patients with low fear displayed a significant avoidance of painful facial expressions, whilst those with high fear displayed a significant bias towards such expressions.

Two former investigations utilising pictorial stimuli have therefore provided support for attentional bias in chronic pain patients at presentation times associated with initial orienting of attention. It is possible that relevant pictorial stimuli may therefore more reliably capture attention in such samples than words stimuli. However, a number of limitations are apparent in these two studies. Specifically, Roelofs et al. (2005) utilised experimental stimuli idiosyncratically chosen by each participant, and it is therefore possible that the difficulties found in disengaging from pain stimuli resulted from recognition of one's previously chosen stimuli. Khatibi et al. (2009) recruited patients with relatively newly developed chronic pain (mean duration 6.7 months), and therefore comparison of these results to those found in previous research is somewhat problematic, as all former investigations have recruited samples with much longer chronic pain durations. Based upon these limitations, the current investigation utilised standardised pictorial stimuli in the form of full colour images, recruiting individuals with chronic headache with pain durations more comparable to samples recruited in former investigations.

Correlates of attentional bias have been frequently explored in past research. Of the individual difference variables explored, a number of studies have provided evidence for a relationship between high fear of pain and attentional bias towards pain-related information (e.g. Khatibi et al., 2009; Asmundson & Hadjistavropoulos,

2007). Additional research, however, has failed to find such effects (e.g. Asmundson, Wright, et al., 2005) or even reported contradictory findings (i.e. slowed responses in patients with high fear; Dehghani et al., 2003). Little evidence has also been found to suggest that additional individual difference variables, including anxiety and depression, underlie attentional bias in chronic pain, although Lioffi et al. (2009) found a strong correlation between trait anxiety and bias towards pain words presented for 500ms. Considering the overall lack of evidence, Asmundson, Wright, et al. (2005) have noted that measures of such variables, including those of anxiety, depression and pain-related fear, may not be powerful predictors of visual-probe results, with further investigation needed.

Based upon the above, the current experiment measured a number of variables which have to date received little attention. The first of these, alexithymia, has been described as a difficulty in identifying, differentiating and communicating one's emotional states (Taylor, Bagby & Parker, 1997). Additional characteristics include difficulties distinguishing different emotional states from one another, and also emotional states from somatic states (Lumley, Asselin & Normal, 1997). High levels of alexithymia have often been found in chronic pain populations (Lumley, Smith & Longo, 2002). Indeed, in the only other relevant investigation to explore this variable, Lioffi et al. found individuals with chronic headache to report significantly higher alexithymia levels than healthy controls. Considering that pictorial stimuli were utilised in the present experiment, it is possible that participants with chronic headache would find it difficult to identify the facial expressions depicted by the models within this stimuli, with attentional bias arising as a result of this difficulty rather than the presence of chronic pain itself. In order to explore this possibility, and to allow for comparison of results with those of Lioffi et al., a measure of alexithymia was therefore included.

According to Wells and Matthews' (1994; 1996) Self-Regulatory Executive Function Model (S-REF), coping strategies which direct attention towards emotionally congruent information are associated with cognitive biases in individuals with emotional disorders. Considering this, coping strategies were also investigated in the current experiment, which have been shown to be of importance in adjustment to chronic pain. For example, while passive coping has been linked to high levels of pain intensity, impairment and low levels of functioning, active coping has been linked to high levels of daily functioning (Ramírez-Maestre, Esteve, & López, 2008). Considering that coping styles are likely to be related to behavioural responses

(Asmundson et al., 1997), it is possible that attentional biases may only be observed in individuals who exhibit specific coping styles. Despite the importance of this question, research to date has yet to investigate this possibility.

In addition to coping styles, a participant's tendency to either seek (monitor) or avoid (blunt) general threatening information (Miller 1987) may correlate with their responses on a visual-probe task also containing emotionally relevant information. Indeed, high monitors have been argued to display vigilance towards threat, amplifying the emotional and cognitive impact of such threats (Miller, Rodollet, Schroeder, Mangan, & Sedlacek, 1996). This notion is also consistent with Wells and Matthews' (1994; 1996) S-REF model noted above. Another variable of importance, pain acceptance, refers to an individual's willingness to live with the presence of chronic pain (McCracken, Vowles, & Eccleston, 2004). Due to the sometimes unpredictable and uncontrollable nature of chronic headache, acceptance may prove to be more beneficial for some patients than continuous attempts to control or cure their condition (McCracken et al., 2004). Indeed, research using explicit measures of acceptance and attention has suggested that individuals who show greater acceptance of their chronic pain pay less attention towards it (Viane, Crombez, Eccleston, Devulder, & De Courte, 2004). Similarly, pain self-efficacy has been found to be significantly predictive of pain and avoidance behaviours, even after controlling for the effects of pain intensity, chronicity and mood (Asghari & Nicholas, 2001). A measure of pain self-efficacy was therefore included. Finally, measures of depression, state and trait anxiety, anxiety sensitivity, pain type and intensity, and headache-related disability were included in order to characterise chronic headache and healthy control samples, and also allowed for a comparison of the current samples to those recruited in previous investigations.

### *Aims and Hypotheses*

The primary aim of this experiment was to investigate the presence of attentional bias in individuals with chronic headache, utilising a visual-probe task with pictorial stimuli, and also to explore whether such bias would vary over two presentation durations of 500 and 1250ms. A secondary aim was to investigate potential underlying correlates of attentional bias. Based upon theoretical models of attention to pain, and relevant theoretical formulations of individual difference variables, the following hypotheses were adopted:

1. Individuals with chronic headache will show a significant attentional bias for headache-related images compared to healthy controls
2. Present pain intensity, monitoring processing style, catastrophising, state and trait anxiety, and anxiety sensitivity will positively correlate with attentional bias, while pain self-efficacy and ignoring of pain will negatively correlate with attentional bias.

### 4.3. Method

#### *Participants*

An a priori power analysis indicated greater than 90% power to detect differences of magnitude 0.6 between groups for a sample size of 32 [(effect size (large) = 0.60, Critical  $F(1, 30) = 4.17$ , Lambda = 11.52; GPower (Erdfelder et al., 1996)]. Participant recruitment strategies and inclusion and exclusion criteria are as specified in the General Methods section of this thesis. A total of 38 participants (mean age = 29.16;  $SD = 13.24$ ; range: 18 to 69 years) participated in this experiment, including 17 meeting the diagnostic criteria for chronic headache (mean age = 30.76;  $SD = 14.74$ ; range: 18 to 69 years) and 21 pain-free, healthy control participants (mean age = 27.86;  $SD = 12.11$ ; range: 19 to 62 years). The majority of participants were female (28; 74%). Eleven (64.7%) of the chronic headache participants had been diagnosed with a tension headache, while the remaining 6 (35.3%) were suffering from migraine. Headache participants had on average 11.06 years ( $SD = 15.56$ ) of headache and were in their majority severely disabled by their headaches as indexed by their MIDAS score (12, 70.6%). The remaining were moderately disabled (1, 5.9%), mild or infrequently disabled (1, 5.9%), and 3 (17.6%) had minimal or infrequent disability. The majority of patients at the time of the study were not taking any analgesic medication regularly (10, 58.8%). The remaining were taking medication on an as-needed basis, including beta-blockers, paracetamol, sumatriptan, combinations of paracetamol and dihydrocodeine, aspirin and non-steroidal anti-inflammatory drugs. Only 6 (35.3%) of the participants had no family (1st degree relative) history of headache. All participants in this investigation had good command of the English language and were either in full-time employment or education. The majority of the participants were married or in a relationship. Based upon the adopted criteria, 3 participants with frequent headaches (i.e. 7 – 10

days per month) were excluded from this investigation who did not meet diagnostic criteria for chronic headache, and 1 (healthy control) due to the presence of a psychiatric disorder.

### *Measures*

The questionnaire measures discussed in the General Methods section in Chapter 1 were included in the current investigation.

### *Experimental Stimuli*

The experimental stimuli included 12 headache-related and 12 neutral (control) images. Headache-related images were selected to show a single model (a) posing in a manner depicting the experience of a headache i.e., holding either their temples or forehead, providing their facial expressions were still visible and (b) having a facial expression depicting the experience of pain. Facial expressions of pain are characterised by 4 actions: lowering the eyebrows; narrowing the eyelids and/or closing the eyes; wrinkling the nose and/or raising the cheeks; partly opening the mouth and/or extending the lips (Craig & Patrick, 1985). Each headache-related image was paired with a neutral image, unrelated to headache or pain, featuring the same model wearing the same clothes, with identical backgrounds. Within these images, models were depicted with neutral expressions devoid of any obvious emotion. Overall, 5 male and 7 female models were depicted in the images. In addition, 12 further image pairs (9 male, 3 female) were selected for filler trials, along with 12 image pairs (8 male, 4 female) for use in practice and buffer trials. All pairs of these images depicted the same respective model with neutral expressions. Across all images, the same model was not included within more than one stimulus pair. Images did not feature any additional objects, as it is likely that such items would distract participant attention away from the models' facial features. All images used in this investigation measured 105mm wide by 71mm high (i.e. 372 pixels by 252 pixels), and were full colour with single-coloured backdrops. Participants were seated approximately 60cm from the computer monitor, with the visual angle of the stimulus 6.88°. Images were matched for brightness, and were either developed specifically for the present investigation or were collected from image databases. An example of the stimuli used in the present investigation is presented in Figure 4.1.

Before final inclusion, all images were rated for (a) the emotion depicted in them and (b) arousal and valence. In preliminary experiment A, ten participants (6

females and 4 males; mean age = 30.6 years old; SD=13.13) rated on a 10cm visual analogue scale (VAS) (0=not at all, 5=moderately, 10=as much as you could imagine) the emotion depicted in a large number of images. Each question began with the following statement ‘To what extent is the person in this image...’, followed by “happy”, “sad”, “angry”, “in pain” and “frustrated”. All images were presented one at a time and in a new random order for each participant. For final inclusion in the visual probe task, all neutral images were required to have mean ratings of 5.0 or lower for happy, sad, angry, in pain and frustrated items. For the headache related images, mean ratings of 7.0 or higher were required for in pain and 5.0 or lower for happy, sad, angry and frustrated items. In preliminary experiment B, the arousal and valence of 144 images, including the ones used in this experiment, were estimated (Schoth & Liossi, unpublished data). Ten participants (5 female, 5 male; mean age = 36.4 years) using a computerised version of the Self-Assessment Manikin method (Bradley & Lang, 1994) rated images individually on a 9-point scale on the emotional dimensions of valence (1 = unpleasant, 5 = neutral, 9 = pleasant) and arousal (1 = calm and 9 = excited). The neutral images used in this visual probe task were chosen to be in the middle range on pleasantness and low on arousal. The results from both preliminary analyses are presented in Appendix B.



Figure 4.1. Example headache-related and neutral stimulus pair utilised in the visual-probe task.

#### *Visual-Probe Task*

A visual-probe task developed using Presentation® software (version 12.2, [www.neurobs.com](http://www.neurobs.com)) was run on an IBM compatible personal computer with a 15-inch

colour monitor. Participants were seated approximately 60cm away from the monitor. A total of 192 experimental trials were included, along with an initial eight practice trials to familiarise participants with the procedure. A break was provided halfway through the task, with the experimental trials split into two 92-trial blocks. Two buffer trials were added to the beginning of each experimental block. The results of practice and buffer trials were not included in the final analyses. In total, the visual-probe task took approximately 12-minutes to complete.

During the visual-probe task, experimental trials were presented continuously in a randomised order, with each trial adhering to the same presentation formula. Specifically, trials began with an initial fixation cross ( + ) being displayed in the centre of the computer monitor for 500ms in size 28 font (approximately 5cm by 5cm). Participants were instructed to focus their attention upon this fixation cross between each trial. Immediately following this presentation, the fixation cross was removed from the display and instantly replaced by a randomly selected image-pair from either the experimental or control image groups. Two time conditions were included in this investigation, and as such the image pairs were displayed for either 500ms or 1250ms. All image pairs were presented vertically in the centre of the display, one above and one below the location of the initial fixation cross. The distance between the inner edges of each image was 3cm. Immediately following the presentation of each image pair, a visual probe was displayed in either the upper or lower location (in approximately the centre of where one image had previously been located). This visual-probe consisted of a white circle, measuring 20 x 20 pixels in height and width (approximately 7mm x 7mm). Participants were instructed to indicate the location of each probe as quickly as possible, with responses recorded via a two-button response box, with buttons marked T and B representing top and bottom responses respectively. Trials were presented in a continuous manner, automatically beginning after each button response. If a participant failed to provide a response within 1500ms, the next trial began automatically. In an attempt to reduce the repetitive nature of the task, a variation in the inter-trial interval was included, with the programme randomly selecting an interval of either 1000 or 1500ms. During the visual-probe task, all text, fixation crosses and probes were presented in white against a black background.

### *Procedure*

The procedure is as specified in the General Methods section of this thesis.

### *Data Reduction and Analytic Plan*

Response times (RTs) from practice and buffer trials were excluded from final analysis, along with any incorrect responses. Inspection of box and whisker plots revealed latencies of below 200ms and above 1000ms as outliers, which were subsequently removed. Following this, mean RTs were calculated for each participant, with any response more than 3 standard deviations away from this mean also removed. Replicating the analytic method of recent visual-probe investigations (i.e. Lioffi et al., 2009), mean response times were first calculated from the raw latencies for each participant. Following this, an index of selective attention was calculated with the raw latency data from experimental trials, with formulas adhering to the following key:  $t$  = target (i.e. headache image),  $u$  = upper,  $l$  = lower and  $p$  = probe. Thus,  $tupl$  represents an incongruent trial, with the target stimulus presented in the upper location and the probe in the lower location. Considering this, the bias index was calculated as follows,  $((tudl - tldl) + (tldu - tudu))/2$ , providing a compound score of a participant's pattern of overall attention. A positive score from this calculation reflects attention directed towards the target stimulus, while a negative score indicates attention directed away from the target stimulus towards the neutral stimulus.

Differences in demographic characteristics between groups were explored with  $\chi^2$  and t-tests for categorical and continuous variables respectively. A  $2 \times 2$  analysis of variance (ANOVA) of attentional bias scores was carried out with group (headache, control) as a between-subjects independent variable (IV), and exposure duration (500, 1250 ms) as a within-subject IV. For this analysis, alpha level was set at .05, two-tailed. Pearson's correlation coefficients were calculated between the attentional bias scores at both exposure durations and the headache-frequency and questionnaire measures. The internal consistency of the self-report measures and their subscales were calculated with the use of Cronbach's alpha (Appendix B). Based upon generally accepted criteria of 0.7 (Nunnally, 1978; Christmann & Aelst, 2006), the following had low internal consistency, and were therefore excluded from the correlational analysis; the MBSS, the externally-oriented thinking subscale of the TAS-20, the praying and hoping subscale of the CSQ, and the MPQ-SF total pain adjective checklist and the sensory pain subscale. All analyses in this investigation were conducted in SPSS 15.0.

## 4.4 Results

### *Group Characteristics*

As shown in Table 4.1, the two groups did not differ significantly in regards to gender ratio or age although, as expected, participants with chronic headache reported significantly more headache days per month than healthy controls.

Table 4.1.

*Group equivalence results (SD) for demographic variables and headache frequency*

Variable	Headache group mean ( <i>n</i> = 17)	Healthy group mean ( <i>n</i> = 21)	<i>t</i> / value/ <i>z</i>	<i>df</i>	<i>SD</i>	<i>p</i>
Headache frequency	18.53 (5.48)	1.62 (1.88)	-13.25	19.07	-	.001
Gender (% female)	13 female 76.5%	15 female 71.4%	.12	1	-	.73
Age (in years)	30.76 (14.74)	27.86 (12.11)	-.28	-	13.24	.79

### *Self-Report Measures*

The mean self-report data for measures completed by both chronic headache and healthy control participants are displayed in Table 4.2. A series of independent t-tests were conducted with Bonferroni correction for multiple comparisons applied, with an accepted alpha of .005 adopted. No significant differences were found between the two groups in relation to any measure. Chronic headache participants also completed additional questionnaires detailing their headache disorder, the results of which are displayed in Table 4.3.

### *Indices of Attentional Bias*

The means for the indices of attentional bias at both presentation times are presented in Table 4.4. The two groups did not differ significantly in the amount of RT data lost due to errors ( $M = 1.4\%$ ,  $SD = 1.3$ ) or outliers ( $M = 4.8\%$ ,  $SD = 1.1$ ), or in overall mean RT ( $M = 473.02\text{ms}$ ,  $SD = 81.47$ ).

Table 4.2

*Comparison of mean (SD) self-report scores for chronic headache and healthy control participants*

Measure	Headache group ( <i>n</i> = 17)	Healthy group ( <i>n</i> = 21)	Mean difference	<i>t</i>	<i>df</i>	<i>p</i>
ASI	19.59 (10.03)	17.71 (9.64)	1.87	.59	36	.56
MBSS sum	5.76 (3.36)	4.05 (2.85)	1.72	1.70	36	.10
STAI state	36.76 (12.17)	32.71 (11.35)	4.05	1.06	36	.30
STAI trait	39.88 (12.31)	35.00 (8.97)	4.88	1.41	36	.17
TAS-20 total	41.18 (11.35)	41.05 (11.56)	.13	-.03	36	.97
TAS-20 - DIE	15.00 (6.33)	13.57 (6.08)	1.43	.71	36	.48
TAS-20 - DDE	10.24 (3.80)	10.86 (4.39)	-.62	-.46	36	.65
TAS-20 – EOT	16.71 (4.17)	16.62 (3.78)	.09	.07	36	.95
HADS anxiety	8.18 (4.97)	5.81 (2.86)	2.37	1.84	36	.07
HADS depression	3.12 (2.74)	1.9 (2.23)	.121	1.51	36	.14

Note: ASI = Anxiety Sensitivity Index; MBSS = Miller Behavioral Style Scale; STAI = State Trait Anxiety Inventory; TAS = Toronto Alexithymia Scale (DIE = difficulty identifying emotions; DDE = difficulty describing emotions; EOT = externally-oriented thinking); HADS = Hospital Anxiety and Depression Scale

#### *Visual-Probe Analysis*

A 2 (headache vs. healthy) x 2 (500 ms vs. 1250 ms) mixed ANOVA was calculated on participant attentional bias scores. There was a significant main effect of group on attentional bias scores,  $F(1, 36) = 4.76, p = .04, \eta_p^2 = 0.12$ . No significant main effect for presentation time was found,  $F(1, 36) = 1.32, p = .26$ , nor a significant interaction between presentation time and group,  $F(1, 36) = .5, p = .49$ . Considering the main effect of group, pairwise comparison revealed the chronic headache group to bias towards headache images significantly more than the healthy control group.

Table 4.3

*Mean (SD) self-report scores for pain measures completed by chronic headache participants*

Measure	Headache group ( <i>n</i> = 17)
CPAQ total	77.18 (16.74)
CPAQ willingness	32.76 (9.30)
CPAQ activities	44.41 (9.07)
Dividing attention CSQ	11.76 (8.86)
Reinterpretation CSQ	6.88 (6.00)
Catastrophising CSQ	9.47 (6.21)
Ignoring CSQ	17.94 (8.93)
Praying CSQ	7.82 (5.11)
Coping CSQ	23.35 (5.96)
IBA CSQ	14.71 (8.35)
Control CSQ	3.71 (1.36)
Decrease CSQ	3.65 (1.37)
MPQ-SF sensory	13.24 (4.22)
MPQ-SF affective	4.12 (3.14)
MPQ-SF total (sensory + affective)	17.35 (6.13)
MPQ-SF current pain	37.12 (30.75)
MPQ-SF overall pain	3.06 (1.14)
PSEQ	41.06 (11.99)

Note: CPAQ = Chronic Pain Acceptance Questionnaire; CSQ = Pain Coping Strategies Questionnaire; MPQ-SF = McGill Pain Questionnaire- short form; PSEQ = Pain Self Efficacy Questionnaire

Table 4.4.

*Mean bias index response scores (SD) for chronic headache (n=17) and healthy control (n=21) participants*

	Headache group		Healthy group	
	500ms	1250ms	500ms	1250ms
Bias Index	4.21 (31.34)	12.83 (27.40)	-8.61 (22.38)	-6.52 (26.22)

*Comparisons to 0*

Attentional bias indices were compared to 0, which theoretically equates to no attentional preference either towards or away from the headache stimuli. For the headache group, bias scores did not differ significantly from 0 at either 500ms (4.21ms,  $SD = 31.34$ ,  $t(16) = 0.55$ ,  $p = .59$ ) or 1250ms (12.83ms,  $SD = 27.40$ ,  $t(16) = 1.93$ ,  $p = .07$ ) presentation times. Similarly, the healthy control group also showed no significant bias at either 500ms (-8.61ms,  $SD = 22.38$ ,  $t(20) = -1.76$ ,  $p = .09$ ) or 1250ms (-6.52ms,  $SD = 26.22$ ,  $t(20) = -1.14$ ,  $p = .27$ ) presentation times. Averaged across both groups, mean attentional bias scores at 500 and 1250ms did not differ significantly from 0 (-2.87 ms,  $SD = 27.15$ ,  $t(37) = -.65$ ,  $p = .52$  and 2.14 ms,  $SD = 28.13$ ,  $t(37) = .47$ ,  $p = .64$  respectively). Individual 95% confidence intervals for both participant groups are shown in Figure 4.2.

*Correlational Analysis*

Pearson’s correlation coefficients were calculated between the attentional bias scores at each exposure duration and the headache-frequency and self-report measures (Kolmogorov–Smirnov tests indicated that the distributions of each score were not significantly different from normal). Due to the high number of correlations, the alpha was adjusted to .01 for these analyses. No significant correlations were found for either the chronic headache or healthy control group. Similarly, when data from both groups were combined, no significant correlations were found. All correlational data is presented in Appendix B.

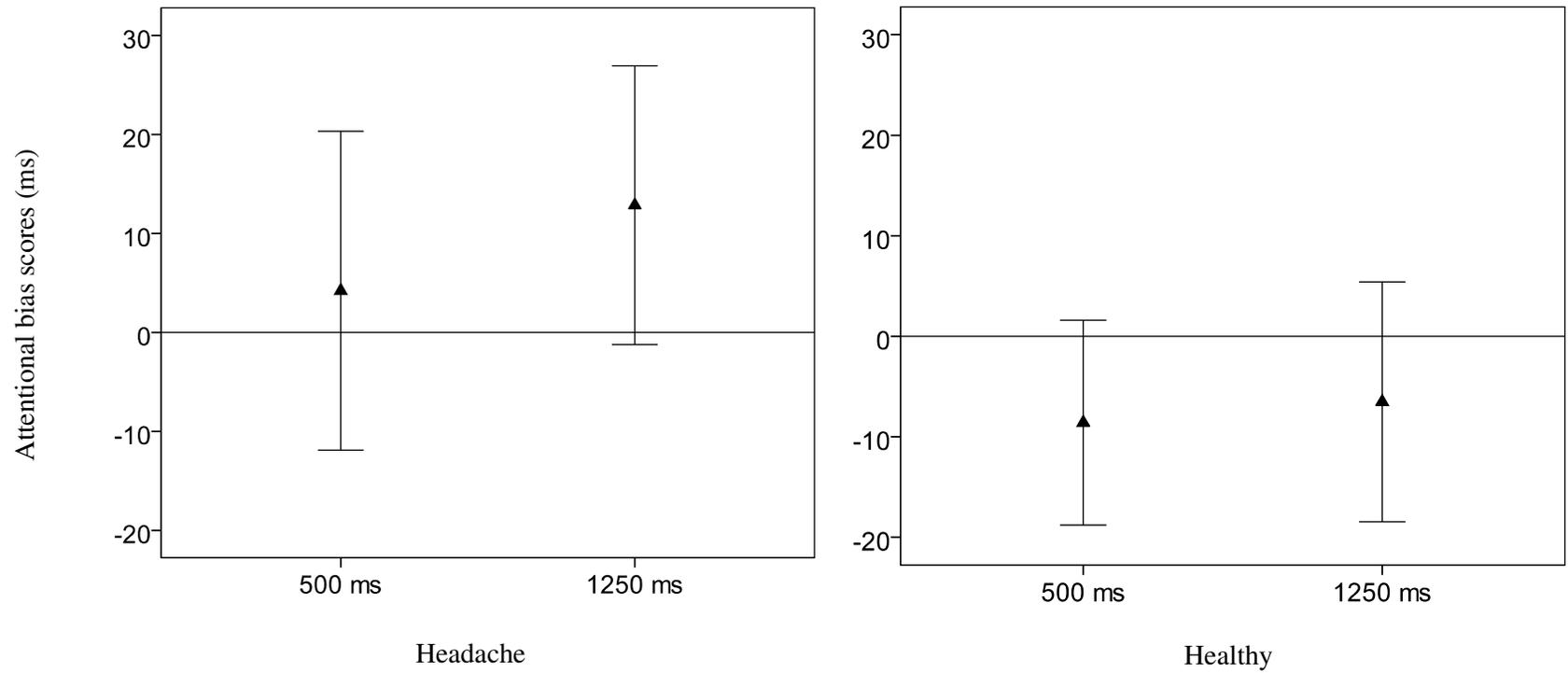


Figure 4. 2. 95% confidence interval error bars for mean attentional bias scores across 500 and 1250 ms presentation times for headache and healthy groups

## 4.5 Discussion

The aim of the current experiment was to investigate the presence of attentional bias in individuals with chronic headache towards relevant pain-related stimuli. Supporting the first experimental hypothesis, participants with chronic headache demonstrated an attentional bias towards headache-related images in comparison to healthy controls. However, this attentional bias was not significantly influenced by stimuli presentation time (i.e. 500 and 1250ms). The results of this experiment therefore add to a growing number of studies (Study 1; Lioffi, et al., 2009; Khatibi et al., 2009; Boyer et al., 2006; Roelofs et al., 2005) supporting the theoretically driven notion (e.g. Pincus & Morley, 2001) that individuals with chronic pain demonstrate attentional bias towards information relevant to their chronic pain condition. Contrary to the second hypothesis no significant correlations were found between attentional bias and any of the self-report measures utilised.

Evidence for the time-course of attentional bias in chronic pain has remained unclear. The meta-analysis presented in Study 1 (Chapter 3) supports the view that, compared to healthy controls, individuals with chronic pain display biases during initial orienting of attention towards pain-related information. The current results build upon this finding, suggesting bias to also exist during the stage of maintained attention, possibly as a result of rumination. Following from Lioffi et al. (2009), the current experiment is the second study to specifically investigate bias at these two attentional stages in individuals with chronic headache. While the overall results of these two studies are in agreement (i.e. those with chronic headache bias towards stimuli relevant to their disorder), Lioffi et al. found evidence for bias during maintained attention only. In contrast, the results of the current experiment suggest bias exists across both initial orienting and maintained stages of attention. One potential explanation for this difference lies in the fact that the chronic headache sample in the current investigation reported significantly greater pain whilst completing the visual-probe task compared to those recruited by Lioffi et al. (current headache group: mean pain VAS = 37.12,  $SD = 30.75$ , versus previous headache group: mean pain VAS = 18,  $SD = 6$ ;  $t(30) = 2.41$ ,  $p < .05$ ). It is possible that levels of current pain intensity may influence the attentional stages at which biases are shown, although to date no research has addressed this

possibility (not all research has even reported pain intensity during the time of testing). Future research would therefore need to investigate this variable, as bias in initial orienting of attention may be related to high levels of present pain.

Differences in pain characteristics may therefore influence attentional bias in chronic pain samples, and may also be responsible for the different pattern of findings reported by Khatibi et al. (2009), who found chronic pain patients with high and low fear of pain to shift attention towards and away from painful facial expressions presented for 300ms respectively. While Khatibi and colleagues recruited patients with pain widespread to many body areas, patients in the current experiment had pain localised in the head region only. Additionally, the former recruited patients with relatively newly developed chronic pain (mean= 6.7 months,  $SD = 1.4$ ), while the current study recruited participants who had experienced persistent pain for a long time (mean= 11.06 years,  $SD = 15.56$ ) [ $t(185) = 3.6, p < .05$ ]. Duration of chronicity has been shown to be an important predictive factor in pain-related disability (Sullivan, Sullivan & Adams, 2002), which itself may be linked with tendencies to bias towards pain-related information. Indeed, Khatibi et al. reported significant correlations between bias towards painful faces and pain disability. Despite these differences, the results from both studies support the use of pictorial stimuli, specifically facial expressions, in such research. Once again, however, the evidence suggests that pain characteristics may have an important affect on attentional bias. Additionally, it is also possible that demographic characteristics such as age may have an affect upon attentional bias, as Boyer et al. (2006) found children with recurrent abdominal pain to attend to pain words presented subliminally, but avoid such words when presented for during the stage of maintained attention. Indeed, saccade latency towards visually presented stimuli has been shown to decrease with age (Salman et al., 2006). An examination of mean response times from the two chronic pain groups revealed overall latencies approximately 23% longer (138.26ms) for stimuli presented at 1250ms by Boyer and colleagues (Boyer et al., 2006) than in the current investigation.

A second aim of the current experiment was to explore potential underlying correlates of attentional bias. The results did not support the hypothesis, as no significant correlations were found between attentional bias and any of the self-report measures utilised. In contrast, Lioffi et al. (2009) found a significant correlation between trait anxiety and bias towards pain words presented for 500ms in individuals with chronic

headache. One possible explanation for these different findings is the lower level of present pain reported by Lioffi et al., as noted above. Aside from this, the two samples did not differ significantly in terms of age, gender or headache frequency (all  $p > .10$ ). Considering self-report measures, the only significant difference found was for the DDE subscale of the TAS-20 (current headache group: mean DDE= 10.24,  $SD=3.80$ , versus previous headache group: mean DDE= 13.93,  $SD= 5.20$ ;  $t(30) = 2.32$ ,  $p = .03$ ), suggesting the former sample to have significantly greater difficulties describing emotions than the current sample.

While the current results did not provide evidence of any significant correlations, it is important to note that the results from past research have provided little consistent evidence for the predictive role of any individual difference variable aside from fear of pain, and even this has been characterised by a degree of inconsistency. Despite this, the current investigation included a number of variables previously unexplored, including coping strategies, information-processing styles, pain self-efficacy, and pain acceptance, all of which were associated with correlational predictions. It is possible that the current results may simply reflect the fact the measures used were not powerful predictors of attentional bias, as Asmundson, Wright, et al. (2005) noted was possible with measures of anxiety, depression, and pain-related fear used in former investigation. An alternative possibility is that attentional bias in chronic pain arises from the presence of chronic pain itself, and not associated levels of emotional or psychological distress, which the current results support. In either case, future research should include larger sample sizes, as a third possibility is that the relatively small sample included in the current study was not large enough to detect significant correlations, especially after adjusting alpha to .01 due to the large number of correlations calculated.

Wells and Matthews (1994; 1996) have argued that cognitive biases in emotional disorders are associated with maladaptive coping strategies which direct attention towards emotionally congruent information. Although the current investigation found no support for this notion in chronic pain, it is important for research to explore additional coping strategies and individual difference variables. In particular, future research would benefit from including self-report measures of pain vigilance and rumination, which have yet to be utilised. Such measures may correlate with biases in initial orienting and maintained attention respectively. Extensive research with clinical anxiety disorders,

which are themselves characterised by hypervigilance for threat, has demonstrated biases at presentation times associated with initial orienting of attention (Bar-Haim, Lamy, Lee, Bakermans-Kranenburg & IJzendoorn, 2007). Considering rumination, research into patients with major depression has found evidence for significant attentional bias towards negative information during maintained attention, a bias that was related to trait rumination (Donaldson, Lam & Matthews, 2007). A tendency to ruminate on pain has been found in individuals with chronic pain, especially in those prone to catastrophising (Thorn, Boothby & Sullivan, 2002), warranting the future investigation of this variable.

Analysis of the various individual difference variables revealed no significant differences between the two groups in terms of psychological or emotional functioning, including anxiety, anxiety sensitivity, depression, alexithymia and information-processing styles. Former research has found inconsistent evidence for such differences, suggesting chronic pain patients to be heterogeneous in regards to associated emotional distress. While Liossi et al. (2009) found individuals with chronic headache to report significantly higher levels of alexithymia than healthy controls, the current investigation did not replicate this finding. However, this also supports the view that the attentional bias observed within the chronic headache group did not arise as a result of difficulties identifying emotional expressions depicted within the pictorial stimuli. Considering chronic pain coping strategies, coping self-statements was the most frequently reported strategy, with 8 (47%) of the chronic headache participants rating this as their most commonly adopted strategy. Ignoring pain was also frequently adopted, being the most common or second most common strategy for 7 (33%) participants. For many individuals, chronic headache is an extremely unpredictable disorder, where headache attacks may occur seemingly randomly without warning. Indeed, qualitative research has found that, for some, the unpredictability of chronic headache negatively impacts upon all areas of life. Individuals who report higher levels of coping report less concern over the unpredictability of their disorder (Leiper, Elliot & Hannaford, 2006). Thus, due to chronic headache unpredictability, coping self-statements and ignoring of pain may be more beneficial strategies than continued focus upon pain or worrying when episodes will occur.

The current experiment attempted to overcome a number of methodological limitations associated with past research (i.e. ambiguous stimuli, heterogeneous pain

samples), although current limitations should be noted. Firstly, the relatively small sample size meant that the study was designed to detect only large effect sizes and the probability of committing a Type II error is increased. Secondly, although attempts were made to make experimental stimuli as specific to headache as possible, facial expressions of pain were necessarily depicted in these images. It is therefore unknown as to whether the current results reflect a bias towards headache-specific stimuli only (i.e. are highly specific), or whether such biases will also be observed towards more general facial expressions of pain. This question is likely to be of clinical importance, as biases towards pain expressions in general may be associated with higher levels of distress and/or impairment. Specifically, if an individual's attention is captured by *any* form of pain-related information, they may experience greater attentional disruption and hence increased psychological distress. In addition to addressing this issue, future research could also investigate alternative types of pictorial threat (including health-threat, general threat) in order to further assess the specific cognitions which may be maladaptive in individuals with chronic headache.

The current results have been interpreted as evidence that individuals with chronic pain demonstrate attentional biases towards pain-related information. An alternative interpretation should be highlighted, however, as it is apparent that the headache-related images utilised depicted additional information aside from pain. While the stimuli employed were selected based upon carefully defined criteria, and further validated by preliminary analysis of emotional content, it is possible that images of models grimacing and holding their heads could be interpreted as expressions of distress such as sadness, anger or other negative emotions. Indeed, preliminary analysis suggested low levels of such emotions present in the stimuli used in the current investigation. Furthermore, attention towards emotional stimuli, such as negative facial expressions including anger, has been argued to be an innate process (Öhman, Flykt, & Esteves, 2001). In order to provide clarification on this, future research is needed to investigate whether chronic pain patients display attentional bias towards facial expressions of negative emotions such as sadness and anger.

In conclusion, results from the current experiment support the presence of attentional bias in individuals with chronic headache towards information related to their pain disorder. The use of pictorial stimuli was supported, which adds to a growing number of studies in suggesting that biases may be more reliably found towards such

stimuli than towards words, for which evidence has been mixed. A number of important questions remain, including the precise time-course of attentional bias in individuals with chronic pain. Relatively few studies have investigated this, however, and differences in chronic pain samples recruited also warrants caution when comparing results. Finally, the current investigation utilised pictorial stimuli of models depicting headaches. Further research is necessary in order to investigate the specificity of attentional bias in chronic pain, including whether individuals with chronic headache display biases towards negative facial expressions (i.e. anger, sadness) in general.

## **Chapter 5**

### **Experiment 2: Attentional bias towards emotional cues in individuals with chronic daily headache.**

#### **5.1. Summary**

This chapter presents the second experiment conducted on the PhD, which was an investigation into attentional bias towards pictorial emotional cues (angry, sad, and happy) in individuals with chronic headache. Forty-six participants took part in this investigation, including 20 with chronic headache and 26 healthy controls. No significant difference was found between these two groups in their patterns of bias towards any of the emotional images. These results therefore expand upon those found in both Study 1 and Experiment 1, together suggesting that attentional biases in individuals with chronic pain are specific towards pain-related information only.

#### **5.2. Introduction**

Research investigating attentional biases in varying disorders has largely been driven by theories of emotional processing, including Wells and Matthews' (1994; 1996) Self-Regulatory Executive Function Model (S-REF) and Bower's network model (1981). Such theories emphasise the presence of information-processing biases associated with information congruent with the individual's emotional concerns or fears. As such, biases should therefore be shown towards specific, relevant information only. While the majority of research investigating bias specificity has been conducted into anxiety and depression, research has also considered specificity in chronic pain. Based upon the theoretical models noted, attentional biases in chronic pain are predicted towards relevant, pain-related information only. Recent research has found evidence that individuals with chronic headache display significantly greater biases towards disorder-relevant pain-related information compared to healthy controls (Liossi, Schoth, Bradley & Mogg, 2009; Experiment 1). However, as both studies employed pain-related information only, it remains unknown whether such biases are specific towards pain

alone. The majority of controlled studies exploring threat bias specificity via the visual probe paradigm have reported no significant differences between chronic pain and healthy control groups, regardless of stimuli type (i.e. Asmundson, Kuperos & Norton, 1997 – pain, injury words; Roelofs, Peters, Fassaert & Vlaeyen, 2005 – sensory pain, affective pain, injury, movement, social-threat words). Asmundson, Wright and Hadjistavropoulos (2005), however, found evidence that chronic pain patients had greater difficulty disengaging from all threat words (i.e. sensory pain, affective pain, health catastrophe). A number of limitations have been noted with these studies (see Study 1 for an in-depth discussion of these studies and their limitations), warranting both caution in the interpretation of their respective results, and the need for further investigation.

In addition to controlled investigations, a number of uncontrolled studies have investigated bias specificity in chronic pain samples alone. The advantage of these investigations has been the recruitment of larger sample sizes, allowing for the detection of smaller effect sizes. Dehghani, Sharpe and Nicholas (2003), recruited 168 patients experiencing chronic musculoskeletal pain, with chronic low back pain the most common pain reported (37.5%). Sensory and affective pain words were included as separate categories, along with disability-related (e.g. *paralysed*, *unhealthy*) and threat (e.g. *fearful*, *danger*) categories. These four word categories were argued to reflect different aspects of pain. All stimuli were presented for 500ms. Following this presentation, a central fixation point was displayed, followed by *P* or *Q* in either the upper or lower location. Participants were required to press the respective keyboard key as soon as the corresponding letter appeared. Providing support for attentional bias, the results showed a significant positive bias towards sensory pain words relative to affective, disability, and negative-threat words (all  $p < .0001$ ). The hypothesis that patients with high fear of pain would show increased bias was not supported.

Despite limitations of utilising a single sample, which will be addressed shortly, these results highlight the importance of investigating sensory and affective dimensions of pain separately (although Lioffi et al. [2009] only found bias towards sensory and affective pain words combined). Since this investigation, members of this research team have conducted two further studies utilising the same stimuli and experimental procedure. Investigating the modification of attentional bias, Dehghani, Sharpe and Nicholas (2004) recruited 42 patients with heterogeneous chronic pain attending a

cognitive behavioural therapy (CBT) programme for pain management. Participants completed three visual-probe tasks; prior to CBT, following CBT (i.e. after 3 weeks) and at one-month follow-up. Prior to treatment, the results showed a significant bias towards sensory pain words relative to affective, disability, and threat words (all  $p < .05$ ), thus replicating the results of Dehghani et al. (2003). Following the completion of the CBT programme, evidence for the same bias towards sensory-pain words was once again found relative to the other three threat types (all  $p < .002$ ). However, during the follow-up session, no significant evidence for bias was found. Most recently, Sharpe, Dear and Schreiber (2009) investigated bias in 100 patients with rheumatoid arthritis. Results showed a significant difference between sensory pain and threat words ( $p = .006$ ). Specifically, significant bias was demonstrated towards sensory pain words ( $p = .04$ ), and significant bias away from threat words ( $p = .026$ ). Examination of congruent and incongruent trial response times confirmed these findings.

The above three investigations, all utilising the same stimuli and visual-probe methodology, have provided evidence that individuals with chronic pain demonstrate significant bias towards sensory pain stimuli specifically. However, the lack of healthy control groups is a problematic issue throughout, as it is impossible to ascertain whether the pattern of biases reported were exclusive to chronic pain patients only, or whether pain-free individuals would have also shown the same attentional patterns. A second limitation concerns a level of ambiguity between stimuli conditions. For example, a number of words in the threat category (i.e. *fearful, frightful, terrifying, scared*) reflect the affective dimension of pain, and could therefore have been theoretically included within the affective category. The notion that all four categories reflect different aspects of pain can therefore be questioned. Thirdly, the lack of neutral control stimuli is problematic, as participants experience threat-related material on every trial. Patterns of attention may therefore be affected, with participants anticipating the appearance of relevant material in every trial. In contrast, the majority of controlled visual-probe studies (aside from Khatibi, Dehghani, Sharpe, Asmundson, & Poureretemad, 2009) have included neutral/neutral filler trials. This may result in more naturalistic patterns of attention, as the appearance of relevant material is more random, and cannot be accurately predicted for any one trial. A final limitation concerns the practice of implementing a second fixation point for 500ms between the word stimuli and subsequent probes (although it is not specified whether this was the case in Sharpe et al.,

2009). While the reasoning for this has not been provided, participant attention is likely to revert back to this point, essentially reducing the ability of the task to adequately detect bias. Thus, this methodology may be primarily suited to detect stronger biases, whereby visual attention remains in the location of the relevant word (in this instance, sensory pain words) despite their disappearance and presentation of a task-irrelevant stimulus. In contrast, weaker biases may be disrupted by this subsequent stimulus presentation, with a visual saccadic eye-movement towards this point. From this central location, participants would respond with approximately equal latencies regardless of whether the subsequent probe was in the upper or lower location.

Research investigating bias in chronic pain has provided evidence that attention is captured by relevant-pain related stimuli. A number of notable methodological limitations have been raised however, warranting the need for further investigation into the specificity of these biases. While the majority of studies have implemented linguistic word stimuli, the use of pictorial stimuli has become more common. The current investigation therefore utilised a visual-probe task with angry, sad, and happy pictorial facial expressions, recruiting both chronic headache and healthy control participants to allow for important between-group comparisons. In addition to exploring the specificity of attentional bias in chronic pain, this experiment also attempted to answer a number of important questions raised by the results of Experiment 1. Pictorial stimuli of facial expressions have been argued to hold advantages over linguistic word stimuli, possessing higher levels of ecological validity and salience (Bradley, Mogg & Miller, 2000). Despite this, degrees of ambiguity may still exist within pictorial stimuli. While a preliminary analysis was conducted in Experiment 1 to develop a stimuli set relevant to the experimental group, it is noteworthy that the images used were inevitably not purely headache-related or neutral. Indeed, low levels of ambiguity were present. For example, while the models depicted in the headache-related images were predominately rated as *in-pain* on a 10cm visual analogue scale (mean: 7.51), lower ratings of *sad* (mean: 4.16) and *anger* (mean: 3.74) were also reported. Although it had been argued that attentional biases in chronic pain are specific towards stimuli relevant to such conditions, an alternative possibility is that such biases are more general, instead being displayed towards any negative emotional facial expression.

Furthermore, evidence has suggested that, although the facial expression of pain is unique and differs (Kappesser & Williams, 2002; Williams, 2002) from expressions of

basic emotions (i.e. anger, sadness, disgust, fear, happiness, surprise and contempt) (Ekman & Friesen, 1986), pain expressions are more akin to a fuzzy set than a prototype (Prkachin & Craig, 1995). Multidimensional scaling of similarity judgements between pain and negative emotion facial expressions has shown pain to fall close to sadness and anger, at the opposite end of the axis from fear, surprise, and disgust (Kappesser & Williams 2002). Considering the points raised, the current experiment sought to establish whether individuals with chronic headache display attentional biases towards negative emotional facial expressions of anger and sadness.

In addition to negative facial expressions, the current experiment also implemented happy facial expressions. Khatibi et al. (2009) utilised happy expressions in a visual-probe task (along with facial expressions of pain), finding both healthy control and chronic pain groups to demonstrate significant bias away from such images. The authors did not provide an explanation for these attentional patterns, however, instead suggesting further research to be necessary. Further to providing clarification of these results, the inclusion of positive facial expressions in the current experiment allowed for investigation of the importance of stimuli valence (i.e. positive vs. negative stimuli). According to the emotionality hypothesis, it is the emotional-nature of a stimulus that is important in determining whether or not an information-processing bias will be displayed, regardless of its valence (Martin, Williams & Clark, 1991). While this hypothesis was developed in relation to generalised anxiety disorder, it is possible that it applies to other disorders such as chronic pain. Emotional difficulties have often been reported in chronic pain (Tüzün, 2007). Should biases be shown towards all emotional cues (supporting the emotionality hypothesis), this may be suggestive that it is these emotional difficulties that are the driving force behind any biases observed, as opposed to chronic pain per se. The current investigation allowed for a testing of this possibility.

To date, only one investigation has explored alternative facial expressions in chronic pain attentional biases (Khatibi et al., 2009). In contrast, a great deal of research has investigated biases towards such stimuli in individuals with emotional disorders such as anxiety. Models of cognition suggest that, within anxiety disorders, information-processing biases are implicated in the causation and/or maintenance of anxiety symptoms, sensitising the patient to potential sources of perceived threat (e.g. Beck, Emery & Greenberg, 1985; Matthews & MacLeod, 2002). Considering studies with pictorial facial expressions, a number of investigations have provided evidence that

individuals with high levels of anxiety demonstrate biases towards angry facial expressions during stages of initial orienting of attention (e.g. Bradley, Mogg, Falla & Hamilton, 1998; Mogg & Bradley, 1999; Mogg, Miller & Bradley, 2000b; Mogg, Garner & Bradley, 2007). In contrast, research into depression has found evidence that individuals with major depressive disorder show biases towards sad facial expressions at attentional stages of maintained attention (Gotlib, Krasnoperova, Yue & Joormann, 2004; Joormann & Gotlib, 2007).

Research into emotional disorders has highlighted the validity of utilising emotional facial expressions, generally finding evidence to support the content-specificity of attentional biases. In addition, it is also notable that time-course is an important factor, with anxiety and depression biases typically shown during stages of initial orienting and maintained attention respectively. Within chronic pain, evidence for the time-course of attentional bias has been inconsistent. While Lioffi et al. (2009) found evidence for bias during maintained attention only, Experiment 1 found evidence for bias across both stages of initial orienting and maintained attention. In order to explore the time-course of bias towards emotional cues, and to allow greater comparison of results to Experiment 1, presentation times of 500 and 1250ms were once again adopted in the current experiment investigating specificity of bias in chronic pain.

### *Aim and Hypothesis*

The aim of this experiment was to investigate whether individuals with chronic headache demonstrate attentional bias towards emotional facial expressions of anger, sadness and/or happiness, relative to both pain-free control participants and neutral facial expressions. Based upon theories of emotional processing (e.g. Wells and Matthews, 1994; 1996; Bower, 1981), the following null hypothesis was adopted:

1. Chronic headache participants will show no significant attentional bias towards angry, sad or happy facial expressions, relative to healthy controls.

### 5.3. Method

#### *Participants*

Participant recruitment strategies and inclusion and exclusion criteria are as specified in the General Methods section. An a priori power analysis indicated greater than 90% power to detect differences of magnitude 0.5 between groups for a sample size of 46 [(effect size (large) = 0.50, Critical F (1, 44)= 4.06, Lambda= 11.50; GPower (Erdfelder et al., 1996)]. Based upon this, a total of 46 participants (mean age, 31.36; SD, 13.44; range 18 to 62 years,) participated in this experiment, including 20 participants meeting the diagnostic criteria for chronic headache (mean age, 33.15; SD, 15.03; range, 18 to 62 years) and 26 pain-free, healthy control participants (mean age, 30.46; SD, 12.26; range, 18 to 55 years). The majority of participants were female (34; 74%). Chronic headache participants reported living with chronic headache for a mean duration of 13.58 years (range 6 months to 45 years), with the majority (15, 75%) severely disabled by their condition, as indexed via their MIDAS scores. Fourteen (70%) of the chronic headache participants were suffering from chronic tension headache, and 6 (30%) from chronic migraine. All chronic headache participants were taking regular medication for their condition, with 9 (45%) reporting regular use of prescription medication (including sumatriptan, amitriptyline, gabapentin and zolmitriptan), and 15 (75%) over-the-counter medication (including paracetamol, aspirin, combinations of paracetamol and dihydrocodeine tartrate, combinations of paracetamol and codeine phosphate, and non-steroidal anti-inflammatory drugs). Thirteen participants (65%) reported at least one immediate blood relatives to also suffer from headache. All participants in this investigation had good command of the English language, and the majority were married or in a relationship. Based upon the adopted criteria, 10 participants with frequent headaches (i.e. 7 – 12 days per month) were excluded from this investigation who did not meet diagnostic criteria for chronic headache, 1 due to secondary chronic headache (attributable to multiple sclerosis) and 1 (chronic headache) due to being over 70 years of age.

### *Measures*

The questionnaire measures discussed in the General Methods were included in the current investigation.

### *Experimental Stimuli*

Four separate image-pair conditions were presented in a visual-probe task, including angry/neutral, sad/neutral, happy/neutral, and neutral/neutral conditions. All experimental stimuli were taken from the NimStim Face Stimulus Set (Tottenham et al., in press), each featuring a full-colour image of a single model against a white background (example stimuli are presented in Figure 5.1). Images were reduced from their original size to 280 pixels high x 218 pixels wide (74 x 57 mm respectively). Participants were seated approximately 60cm from the computer monitor, with the visual angle of the stimulus 7.07°. All stimuli models wore a grey covering from the neck downwards, therefore hiding their clothes. The same model was included in both images for each image pair, and in all cases was staring directly at the camera.



Figure 5.1. Example sad and neutral NimStim stimulus pair (no. 03) utilised in the visual-probe task.

For each of the three emotional image groups (i.e. angry, sad and happy), an emotional expression was paired with a neutral expression, with the model in the same position and distance from the camera. The emotional expressions corresponded with descriptions provided by Ekman and Friesen (1975). Specifically, angry expressions

featured lowered eyebrows, tightened lower eyelids and stretched lip corners. Half of these images featured open mouths, partially revealing the teeth. Sad expressions featured models with down-turned lip corners and furrowed brow. Seventy percent of images featured models with open mouths. Happy expressions featured models with mouths upturned at both ends (i.e. smiling), raised cheeks, and tightening of the eye lids. Half of these images featured models with open mouths. Finally, neutral images depicted the model with no discernable emotional expression. In all emotional/neutral images pairs, the model's mouth was matched (i.e. both open or both closed). For the neutral/neutral condition, images in each pair were similar, although not identical. Specifically, one image featuring the model with the mouth slightly open, and the other image the same model with the mouth closed. Each of the four image groups consisted of ten unique images-pairs, which were as follows (number indicates NimStim code):

- Angry / Neutral: 07, 08, 10, 17, 24, 25, 34, 40, 41, 45
- Sad / Neutral: 03, 05, 12, 18, 27, 30, 32, 36, 37, 38
- Happy / Neutral: 02, 06, 11, 16, 19, 20, 22, 26, 33, 44
- Neutral / Neutral: 01, 09, 12, 14, 15, 21, 23, 28, 31, 39

A total of 6 male and 4 female models were included within the angry/neutral and sad/neutral conditions, whilst 5 male and 5 female models were included within the happy/neutral and neutral/neutral conditions. In addition images, 8 practice neutral/neutral images pairs were also included to familiarise the participant to the task. These images were collected from image databases, and also featured the same model against a white background. Finally, 4 buffer neutral/neutral images pairs were included in the main task, which were taken from the NimStim Face Stimulus Set (Tottenham et al., in press). These images met the same criteria as those included in the neutral/neutral experimental group, although featured different models (29, 35, 42, 43).

Prior to inclusion in the visual-probe task, a preliminary analysis of the valence and arousal of the experimental stimuli was conducted with a computerised version of the Self Assessment Manikin (SAM; Lang, 1980). All images were randomly presented to participants for 3 seconds each. Following this, two 9-point SAM scales were presented, including one for valence and one for arousal. Participants were instructed to

indicate how happy and aroused they felt whilst viewing each image, using the computer mouse to provide their responses on the valence and arousal SAM scales respectively. A total of 10 participants (4 male, 6 female) completed this rating task (mean age 24.90; *SD*. 3.54), the results of which are presented in Table 5.1.

Bonferroni correction for multiple comparisons was applied, with an accepted alpha of .004 adopted. Angry images were rated as significantly more arousing than their neutral counterparts ( $t(9)= 5.01, p= .001$ ). Sad images were rated as significantly less pleasant ( $t(9)= -6.09, p< .001$ ) and significantly more arousing ( $t(9)= 4.71 p= .001$ ) than their neutral counterparts. Happy images were rated as significantly more pleasant ( $t(9)= 7.97, p< .001$ ) and arousing ( $t(9)= 9.00, p< .001$ ) than their neutral counterparts. Comparing emotional images to each other, both angry ( $t(9)= 13.29 p< .001$ ) and sad ( $t(9)= -17.27, p< .001$ ) images were significantly less pleasant than happy images.

Table 5.1

*Mean (SD) valence and arousal of experimental and control stimuli used in the visual-probe task*

Image condition	Valence	Arousal
Angry	3.40 (.70)	5.10 (.74)
Sad	3.40 (.52)	4.10 (.74)
Happy	6.50 (.53)	4.30 (.48)
Angry-Neutral	4.70 (.68)	3.30 (.68)
Sad-Neutral	4.70 (.48)	3.00 (.00)
Happy-Neutral	4.80 (.42)	3.10 (.32)
Neutral/Neutral control	4.70 (.47)	3.00 (.46)

#### *Visual-Probe Task*

A visual-probe task developed using Presentation® software (version 12.2, www.neurobs.com) was run on an IBM compatible personal computer with a 15-inch colour monitor. A total of 320 experimental trials were presented to participants, along

with 8 practice and 4 buffer trials. A break was provided after 160 experimental trials (approximately 10 minutes), with the total visual-probe task taking approximately 20 minutes to complete.

Similar to Experiment 1, experimental trials were presented in a new random order for each participant. Each trial began with the display of a fixation cross for 500ms, followed by the presentation of a random image-pair for either 500 or 1250ms. Differing to Experiment 1, the images in this study were presented horizontally to the left and right of the initial fixation cross. As images were longer vertically, this change was made to ensure that both stimuli would be displayed in each trial without any cut off. The distance between the inner edges of the two images was 5cm. A two-button response-box was used by participants to indicate the location of a following probe, with 'L' and 'R' labels representing left and right responses respectively. Aside from the presentation of different stimuli horizontally (as opposed to vertically), the visual-probe specifics were identical to those described in Experiment 1.

### *Procedure*

The procedure is as specified in the General Method section of this thesis

### *Data Reduction and Analytic Plan*

All results were analysed in SPSS 15.0 for Windows. Buffer and practice trials were excluded from final analysis, along with any incorrect responses. Box and whisker plots for overall data revealed outliers to be any response latencies falling below 200ms or above 1000ms. Following this, mean response times were calculated for each participant, with any responses more than 3 standard deviations away from this mean also removed as outliers. Bias indices were calculated from the raw data in the same manner specified in Experiment 1. Differences in demographic characteristics between groups were explored with  $\chi^2$  and t-tests for categorical and continuous variables respectively. A  $2 \times 2 \times 2$  analysis of variance (ANOVA) of attentional bias scores was carried out with group (headache, control) as a between-subjects independent variable (IV), and exposure duration (500, 1250 ms) and image type (angry, sad, happy) as within-subject IVs. For this analysis, alpha level was set at .05 two-tailed. Pearson's correlation coefficients were calculated between the attentional bias scores at both exposure durations with the self-report measures and headache-frequency. The internal

consistency of the self-report measures and their subscales were calculated with the use of Cronbach's alpha (Appendix C). Based upon generally accepted criteria of 0.7 (Nunnally, 1978; Christmann & Van Aelst, 2006), the externally-oriented thinking subscale of the TAS-20 and the MBSS showed poor consistency, and were therefore not included in the correlational analysis.

## 5.4. Results

### *Group Characteristics*

To assess group equivalences, an independent samples t-test was conducted on *headache frequency*, while a chi-square analysis was conducted on the variable of *gender*. *Age* was found to be negatively skewed upon histogram inspection, and therefore a Mann Whitney U test was performed on this variable. As shown in Table 5.2, no significant differences between chronic headache and healthy groups were found for either *age* or *gender*, although as expected significantly more headache days per month were reported by the former.

Table 5.2

*Group equivalence results (SD) for demographic variables and headache frequency*

Variable	Headache group ( <i>n</i> = 20)	Healthy group ( <i>n</i> = 26)	<i>t</i> / value/ <i>z</i>	<i>df</i>	<i>p</i>
Headache frequency	22.35 (7.16)	1.69 (1.54)	14.33	20.36	.001
Gender (% female)	16 female (80%)	18 female (69%)	.68	1	.41
Age (in years)	33.15 (15.03)	30.46 (12.26)	.01	-	.99

*Self-Report Measures*

The mean self-report data for measures completed by both chronic headache and healthy control participants are displayed in Table 5.3. A series of independent t-tests were conducted with Bonferroni correction for multiple comparisons applied, with an accepted alpha of .005 adopted. Based upon this, significantly higher levels of depression (HADS;  $p < .001$ ) were reported by chronic headache participants compared to healthy controls. Chronic headache participants also completed additional questionnaires detailing their headache disorder, the results of which are displayed in Table 5.4.

Table 5.3

*Comparison of mean (SD) self-report scores for chronic headache and healthy control participants*

Measure	Headache group ( $n = 20$ )	Healthy group ( $n = 26$ )	Mean difference	$t$	$df$	$p$
ASI	26.75 (11.99)	19.42 (10.68)	7.33	2.19	44	.034
MBSS sum	7.05 (3.03)	5.35 (3.72)	1.70	1.67	44	.103
STAI state	39.90 (14.23)	35.12 (7.39)	4.79	1.37	26.83	.182
STAI trait	44.05 (14.50)	37.62 (9.86)	6.44	1.79	44	.080
TAS-20 total	50.25 (13.36)	44.15 (13.37)	6.10	1.53	44	.132
TAS-20 - DIE	19.35 (7.46)	14.65 (6.29)	4.70	2.32	44	.025
TAS-20 - DDE	12.70 (5.28)	11.73 (5.26)	.97	.62	40.97	.539
TAS-20 – EOT	18.20 (3.79)	17.77 (4.58)	.43	.34	44	.735
HADS anxiety	9.65 (5.44)	6.62 (3.58)	3.04	2.16	31.13	.039
HADS depression	6.55 (3.83)	2.46 (2.39)	4.09	4.19	30.01	.001

Note: ASI = Anxiety Sensitivity Index; MBSS = Miller Behavioral Style Scale; STAI = State Trait Anxiety Inventory; TAS = Toronto Alexithymia Scale (DIE = difficulty identifying emotions; DDE = difficulty describing emotions; EOT = externally-oriented thinking); HADS = Hospital Anxiety and Depression Scale

Table 5.4

*Mean (SD) self-report scores for pain measures completed by chronic headache participants*

Measure	Headache group ( <i>n</i> = 20)
CPAQ total	60.75 (20.63)
CPAQ willingness	25.15 (12.27)
CPAQ activities	35.60 (10.20)
Dividing attention CSQ	10.10 (6.21)
Reinterpretation CSQ	7.05 (5.84)
Catastrophising CSQ	14.20 (7.50)
Ignoring CSQ	15.50 (7.82)
Praying CSQ	10.50 (9.42)
Coping CSQ	21.30 (7.48)
IBA CSQ	13.35 (7.68)
Control CSQ	2.90 (1.33)
Decrease CSQ	2.75 (1.33)
MPQ-SF sensory	16.55 (5.94)
MPQ-SF affective	4.95 (3.22)
MPQ-SF total (sensory + affective)	21.50 (8.45)
MPQ-SF current pain	45.50 (31.33)
MPQ-SF overall pain	3.30 (1.08)
PSEQ	34.65 (14.18)

Note: CPAQ = Chronic Pain Acceptance Questionnaire; CSQ = Pain Coping Strategies Questionnaire; MPQ-SF = McGill Pain Questionnaire- short form; PSEQ = Pain Self Efficacy Questionnaire

*Indices of Attentional Bias*

The means (SD) for the various indices of attentional bias are presented in Table 5.5. The two groups did not differ significantly in the amount of RT data lost due to

errors ( $M = 1.11\%$ ,  $SD = 1.04$ ) or outliers ( $M = 1.47\%$ ,  $SD = .69$ ), or in overall mean RT ( $M = 397.53\text{ms}$ ,  $SD = 63.32$ ).

Table 5.5

*Mean bias index response scores (SD) for chronic headache and healthy participants across all image conditions*

	Headache ( $n = 20$ )		Healthy ( $n = 26$ )	
	500ms	1250ms	500ms	1250ms
Bias Index – Angry	7.22 (15.23)	9.11 (21.47)	10.46 (24.55)	8.77 (22.91)
Bias Index – Sad	3.36 (24.72)	5.23 (21.16)	15.77 (20.34)	8.63 (22.13)
Bias Index – Happy	-.91 (26.21)	4.26 (15.18)	-.65 (18.25)	9.72 (24.48)

#### *Visual-Probe Analysis*

A 2 (*group*; chronic headache vs. healthy) x 2 (*presentation time*; 500 ms vs. 1250 ms) x 3 (*image type*; angry vs. sad vs. happy) mixed designs ANOVA was conducted on participant *bias index* data. The results showed no significant main effect of *group*,  $F(1, 44) = 3.14$ ,  $p = .08$ , *image type*,  $F(2, 88) = 1.48$ ,  $p = .23$ , or *presentation time*,  $F(1, 44) = .65$ ,  $p = .42$ . No significant interactions were found for *presentation time* x *group*  $F(1, 44) = .33$ ,  $p = .57$ , *presentation time* x *image type*,  $F(2, 88) = 1.41$ ,  $p = .25$ , or *group* x *image type*,  $F(2, 44) = .42$ ,  $p = .66$ . Finally, no significant interaction was found for *presentation time* x *image type* x *group*,  $F(2, 44) = .62$ ,  $p = .54$ . Depression scores were not included as a covariate in an ANCOVA as two assumptions were violated: 1) no significant correlations were found between depression scores with any of the bias indices, 2) Levene's test for homogeneity revealed unequal variances between chronic headache and control groups ( $F = 9.35$ ,  $p = .004$ ). Due to these

violations of the ANCOVA statistic, depression was not included as a covariate (Tabachnik & Fidell, 2001), a process adopted in other research (i.e. Khatibi et al., 2009).

#### *Comparisons to 0*

Attentional bias indices were compared to 0, which theoretically equates to no attentional preference either towards or away from the target stimuli. Considering groups separately, chronic headache participants showed a significant bias towards angry expressions at 500ms,  $t(19) = 2.12, p = .05$ . Healthy participants showed significant bias at 500ms towards angry,  $t(25) = 2.17, p = .04$ , and sad,  $t(25) = 3.95, p < .001$ , expressions, and at 1250ms towards happy expressions,  $t(25) = 2.02, p = .05$ . When data from the two groups were combined, significant biases towards angry expressions were found at both 500ms,  $t(44) = 2.94, p = .01$  and 1250ms,  $t(44) = 2.74, p = .01$ , towards sad expressions at 500ms,  $t(44) = 3.07, p < .01$ , and 1250ms,  $t(44) = 2.25, p = .03$ , and finally happy expressions at 1250ms,  $t(44) = 2.38, p = .02$ . Individual 95% confidence intervals for all image groups across both participant groups are shown in Figure 5.2.

#### *Correlations between Indices of Attention and Self-Report Measures*

Correlations between the various self-report measures and the indices of attentional bias were computed, with the alpha level adjusted to  $p < .01$  due to the high number of calculations. The full correlation matrices can be found in Appendix C, Tables 2 to 4. Considering results per group, examination of the chronic headache group at the 500ms presentation time revealed a positive correlation between state anxiety (measured via the STAI) and the happy bias index,  $r = .676, p = .001$ . No significant correlations were found at the 1250ms presentation time. For the healthy control group, no significant correlations were found at either 500 or 1250ms presentation times. In addition to separate group analyses, all participants were included together in an overall correlational analysis ( $N = 46$ ). At the 500ms presentation time, state anxiety (measured via the STAI) was once again positively correlated with the happy bias index,  $r = .407, p = .005$ . No other significant correlations were found at either 500 or 1250ms presentation times.

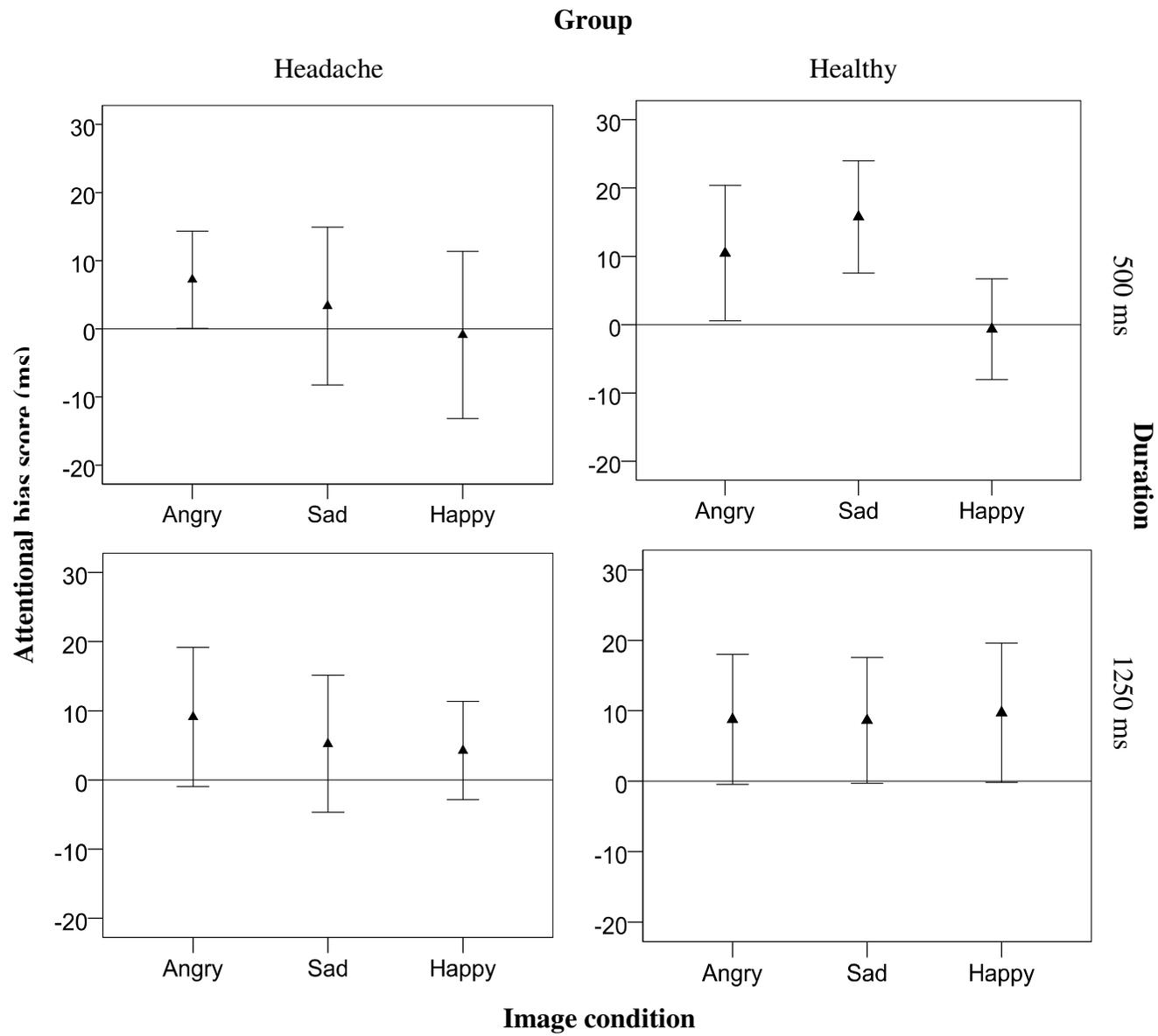


Figure 5.2. 95% confidence interval error bars for mean attentional bias scores across all image conditions for headache and healthy groups

## 5.5. Discussion

The aim of this experiment was to investigate whether individuals with chronic headache differ to healthy controls in their patterns of attention towards emotional facial expressions. Supporting the adopted null hypothesis, no significant difference between these two groups was found. In combination, the results from Lioffi et al. (2009), Experiment 1, and the current experiment indicate that, compared with healthy controls, individuals with chronic headache demonstrate biased attention towards headache-related information only. These results are therefore in agreement with theories of emotional processing, including Wells and Matthews' (1994; 1996) S-REF model and Bower's (1981) network theory, which suggest processing biases are associated with information relevant to the individual's concerns only.

The results from Experiment 1 provide evidence that individuals with chronic headache demonstrate attentional biases towards headache-related pictorial stimuli. However, preliminary analysis of the images used highlighted the presence of information other than pain (e.g. low levels of anger and sadness). An alternative interpretation of these results is that individuals with chronic headache biased towards the experimental stimuli due to this additional emotional content. If this were the case, the argument that attentional biases in chronic pain are specific towards pain-related information would be weakened. The results from the current experiment provide important information pertaining to this, as individuals with chronic headache did not significantly differ to healthy controls in their patterns of attention towards angry or sad emotional facial expressions. In addition to negative emotional expressions, positive happy facial expressions were also included in the visual-probe task, with no significant difference found between the two groups in their attentional patterns towards such images. While Khatibi et al. (2009) also reported no significant between-group differences, both groups were found to significantly bias away from happy faces presented for 300ms. In contrast, the current investigation found bias indices close to 0 at the 500ms presentation time, indicating almost equal processing of happy images and their neutral counterparts. The reasons for these different findings are unknown, although a number of important differences between the two chronic pain groups exist, including newly developed musculoskeletal pain vs. long term chronic headache.

However, these differences fail to explain why the healthy control groups also exhibited different attentional patterns. An alternative explanation concerns the fact that different stimuli sets were utilised by the two studies, which may therefore be responsible for these overall discrepancies. It still remains unknown, however, as to why participants in the former investigation would demonstrate such strong avoidance of positive, happy emotional expressions.

Considering individual difference variables, the current experiment found significantly higher levels of depression in the chronic headache group. While it cannot be proven, it can be speculated that this heightened depression resulted from the experience of living with chronic pain. Indeed, research has commonly reported heightened emotional disturbances in individuals with chronic pain (Tüzün, 2007), with recent research reporting 35% of individuals with chronic pain to also exhibit comorbid depression (Miller & Cano, 2009). However, comorbid depression was one of the exclusion criteria adopted in the current experiment. Therefore, although depression levels were higher in the chronic headache group compared to controls, no individuals with clinical depression were included. Accordingly, the lack of bias towards sad facial expressions in the chronic pain group is unsurprising. These findings also match predictions raised by the Schema Enmeshment Model of Pain (Pincus & Morley, 2001), which states that biases towards depressive and affective distress information will only be seen in individuals with chronic pain who have a history of depression and are currently depressed.

While the current results revealed no significant between-group differences, comparisons to 0 showed some variation between chronic headache and healthy controls. When analysed separately, both groups demonstrated bias greater than 0 towards angry facial expressions at 500ms only, a finding perhaps unsurprising given the notion that humans are evolutionary primed to attend towards threatening information to aid survival (e.g. Mogg & Bradley, 1998; Öhman & Mineka, 2001). Indeed, such biases should be stronger at presentation times associated with initial orienting of attention, given that passive, stimulus-driven attentional processes aimed at maintaining survival are argued to bias attention rapidly and automatically (Öhman, Flykt & Esteves, 2001). However, it is important to note that, when combined, an overall bias towards angry expressions was also found at 1250ms. While similar attention was displayed towards angry faces, the two groups differed in that healthy controls also showed greater bias

towards sad images presented for 500ms, and happy images presented for 1250ms. As healthy control participants reported significantly lower depression, happy facial expressions may have been more relevant to their current mood, hence a tendency to favour these images over their neutral counterparts. However, the bias observed towards sad images at 500ms counters this explanation. An alternative explanation is that healthy controls favour emotional expressions over neutral expressions, regardless of valence. Concerning time-course, negative information appears to be favoured at shorter presentation times, and positive information at longer presentation times. Öhman, Lundqvist and Esteves (2001) have provided evidence from a number of experiments that threatening faces (e.g. angry expressions) are detected faster and more accurately than positive, happy expressions. This pattern of findings was not found with sad faces, however, which is discrepant with the current results. Despite this latter inconsistency, the results from the current experiment support the notion that angry facial expressions are evolutionary primed to quickly capture attention. The lack of difference between chronic headache and control groups further supports this as a universal mechanism.

Correlational analysis revealed state anxiety to be significantly correlated with the happy bias index at 500ms for the chronic headache group. While this correlation was also found with all participant data combined, examination of results indicates this result to be driven by the chronic headache group, as a non-significant negative correlation was found for the control group. Thus for those with chronic headache, increases in state anxiety were related to an attentional preference for happy facial expressions during initial orienting of attention. One potential explanation for this finding is that, as state anxiety increases, biases towards positive information are displayed in order to try and reduce anxiety. A distinction between automatic and deliberate mood regulation has been proposed (Mauss, Cook & Gross, 2008), with the current research finding evidence for the former only. Emotion regulation strategies may not have been engaged in deliberately (i.e. at 1250ms), however, as anticipation of the upcoming probe, and the necessary motor response, may have overridden any conscious tendencies to predominately monitor one of the stimuli pair. In contrast to these findings, Khatibi et al. (2009) reported no significant correlations between anxiety and bias towards happy facial expressions presented for 300ms. However, once again, the many differences between this study and the current investigation limit the ability to reliably compare results. Aside from these two investigations, no other visual-probe study

investigating chronic pain attentional bias has implemented stimuli of positive valence. Further research utilising such stimuli is therefore needed in order to gain a better understanding of processes of automatic and deliberate emotion regulation in chronic pain.

Aside from the above, no other significant correlations were found between any of the individual-difference variables reported and the various bias indices. This is somewhat surprising, as a correlation between anxiety and angry faces would be expected. Considering former chronic pain research, it is notable that evidence for significant correlations have been largely inconsistent, although differences in both sample and stimuli characteristics, along with the use of differing questionnaire measures, are likely to provide some explanation. Aside from Khatibi et al. (2009), however, no former investigations in this field of research have adopted emotional facial expressions other than pain. It is uncertain, therefore, whether the general lack of correlations witnessed in the chronic headache group are typical of chronic pain, or specific to this sample. Further research with emotional cues will be able to provided answers to questions such as these.

A limitation of the current investigation was the lack of inclusion of pain-related facial expressions. This decision was made in order to keep the visual-probe task to a reasonable duration (i.e. approximately 20 minutes), as effects upon participant burden are an important consideration in such research (Kellough, Beevers, Ellis, & Wells, 2008). This is especially true for clinical samples, who already exhibit physical and psychological burdens (Ulrich, Wallen, Fester & Grady, 2005). As a consequence, however, the argument for bias specificity in chronic headache can only be made indirectly, via a consideration of combined results from Lioffi et al. (2009), Experiment 1, and the current experiment, all of which used comparable samples in terms of chronic pain aetiology and chronicity. In order to clarify the content-specificity of attentional bias in chronic headache, further research is necessary, presenting pain-relevant and general threat stimuli to the same chronic headache and healthy control samples. To date, no published research has performed this with pictorial stimuli. A second limitation of the current investigation was the relatively small sample size, which only allowed for the detection of large effect sizes. Should smaller differences exist between the two groups, the current investigation would not have been able to detect these. Future research would therefore benefit from the recruitment of larger samples sizes in order to

investigate this issue. Finally, as all participants with chronic headache reported the use of regular pain medication, the possibility remains that such medication had an affect upon response times. However, overall mean response times did not significantly differ between chronic headache and healthy control groups, suggesting this to not be of significant concern in the current investigation.

In conclusion, the results from the present investigation provide clarification of those reported in both Study 1 and Experiment 1, which together suggest attentional biases in chronic pain are specific towards pain-related information only. Such bias specificity shows agreement with a number of theories of emotional processing (e.g. Wells & Matthews, 1994; 1996; Bower, 1981). While individuals with chronic headache do not display significantly greater biases towards emotional facial expressions relative to healthy controls, a number of important questions pertaining to bias specificity remain. Firstly, the current investigation included pictorial stimuli depicting interpersonal threat in the form of angry and sad facial expressions. Research has yet to consider whether chronic pain and healthy controls samples differ in their responses to more generalised threat images portraying dangerous objects and scenes (e.g. fire, vehicular accidents). Due to important differences between such stimuli, it is premature to conclude from the current results that chronic pain and healthy control samples do not differ in their attentional patterns towards *all* forms of non-pain related threat. Secondly, it remains unclear as to whether biases in chronic pain are specific towards disorder-relevant stimuli only, or are also shown towards general pain-related information. This is an important consideration, as bias towards all forms of pain-related information may be indicative of poorer coping. This also raises the important question as to whether biases in chronic pain are similar for all individuals, or whether variables such as coping appraisals affect the types of pain information towards which biases are shown. Finally, there is currently a lack of knowledge regarding whether individuals with chronic pain demonstrate biased attention towards health-threat information associated with their medical condition (e.g. wheelchairs, ambulances). Once again, different patterns of bias may be evident, as only individuals significantly concerned over medical treatment or negative future outcomes may bias towards such information. Based upon questions such as these, it is apparent that further investigation into the specificity of attentional biases in chronic pain is needed.

## **Chapter 6**

### **Experiment 3: Specificity and Time-Course of Attentional Bias in Chronic Headache; the Importance of Disorder-Specific Information**

#### **6.1. Summary**

This chapter presents the third experiment conducted on the PhD, which was an investigation into the specificity and time-course of attentional bias in individuals with chronic headache. A total of 75 participants were recruited, including 37 meeting the diagnostic criteria for chronic headache, and 38 healthy controls. Headache, pain, health threat and general threat images were presented in a visual-probe task for both 500 and 1250ms. Individuals with chronic headache, compared to healthy controls, demonstrated significantly greater attentional bias towards headache images presented for 1250ms. When compared to 0 (which indicates no bias), the chronic headache group demonstrated significant biases towards headache images at both 500 and 1250ms presentation times, and towards pain images at 500ms. The healthy control group, alternatively, showed significant bias towards general threat images presented for 500ms. Overall, these results support and expand upon those presented in Experiments 1 and 2, suggesting individuals with chronic headache bias attention towards information specific to their particular medical disorder, at presentation times associated with both initial orienting and maintained attention.

#### **6.2. Introduction**

According to theories of emotional processing (Wells and Matthews, 1994; 1996; Bower, 1981), individuals are predicted to display cognitive-processing biases towards information associated with their fears and concerns. An understanding of such distortions or biases is likely to be important from both clinical and theoretical perspectives. Specifically, it has been argued that the cognitive distortions of various disorders may be associated with particular behaviours, some of which may be

maladaptive (Westra & Kuiper, 1997). Cognitive biases in social phobia, for example, have been argued to predict anxiety and avoidance behaviours of social situations deemed threatening (Kimbrel, 2008), with negative effects upon health, education, and career among others (Wittchen, Fuetsch, Sonntag, Müller, & Liebowitz, 2000). Thus, evidence of cognitive distortions or biases may be useful predictors for clinical intervention, including psychological treatments (Pincus & Morley, 2001).

Chronic pain disorders have been subject to increased investigation in recent years, with particular emphasis upon cognitive biases in attention. The results of the current programme of research have provided evidence that individuals with chronic pain display significantly greater attentional bias towards pain-related information compared to pain-free controls. This support has come from a meta-analysis of former visual-probe investigations (Study 1), and an empirical experiment investigating bias in chronic headache towards headache-related images (Experiment 1). Further to investigating the presence of bias, a specific aim of this thesis is to examine the specificity of bias in chronic pain. In regards to this, Experiment 2 investigated bias towards angry, sad, and happy facial expressions, finding no significant differences between chronic headache and healthy control groups in regards to patterns of attentional bias. Thus, in combination, the results presented thus far in this programme of research support the notion that biases in chronic pain are specific towards pain-related information. Despite this support, a number of important questions have yet to be addressed in the relevant literature. Specifically, it remains unknown as to whether biases in chronic pain are disorder-specific only, or are shown towards, a) more general pain information, b) information representing threat to health, and c) non-pain related depictions of threat. Further research is therefore warranted into bias specificity in chronic pain.

As noted, the results of Experiment 1 provided evidence that individuals with chronic headache demonstrate significant bias towards headache-related images. These images featured models holding either their temples or forehead while depicting a facial expression of pain. It is therefore unknown as to whether individuals with chronic headache bias their attention towards disorder-relevant information only, or also towards more general pain information. In order to investigate this, the current experiment included both headache images and facial expressions of pain within a visual-probe task. Should bias be specific towards disorder-related information only, significant bias would

not be expected towards images depicting facial expressions of pain alone. To date no former research has investigated this potentially important stimuli distinction, although implications upon patients' daily functioning may exist. Specifically, bias towards all forms of pain information is likely to be more cognitively intrusive than bias towards disorder-specific information only. Despite this lack of specific investigation, it is important to note that Khatibi, Dehghani, Sharpe, Asmundson, and Pouretmad (2009) found no evidence for bias towards painful expressions in a group of patients with chronic musculoskeletal pain compared to controls. Only when the pain sample was split into high and low fear of pain were significant biases found towards and away from painful expressions respectively.

Understanding the specific concerns and fears a patient may have is likely to be an important factor in patient treatment. Research investigating patients with chronic pain has highlighted a high prevalence of health anxiety in such samples, which can be defined as "concern about health in the absence of pathology or excessive concern when there is some degree of pathology" (Lucock & Morley, 1996. p137). Hypochondriasis is considered an extreme form of health anxiety, and is characterised by "excessive preoccupation with disease in the absence of supporting medical evidence or despite medical reassurance" (Hadjistavropoulos, Hadjistavropoulos, & Quine, 2000). Analysing questionnaire data from 170 patients with chronic pain, Rode, Salkovskis, Dowd, and Hanna (2006) found evidence of high health anxiety in 51.1% of patients, and hypochondriasis in 36.7% of patients. While health anxiety can be adaptive in certain situations, promoting the seeking of medical intervention, maladaptive health anxiety is argued to be "out of proportion with the objective degree of medical risk" (Taylor & Asmundson, 2004. p 2). Thus, the high levels of health anxiety found in individuals with chronic pain is of considerable concern, as a host of negative experiences have been associated with such conditions, including emotional distress, physiological arousal, and intrusive thoughts and concerns (Taylor & Asmundson, 2004).

Based upon the above, the current investigation sought to examine whether individuals with chronic headache bias their attention towards information representing threat to health; a variable that has received limited consideration in former research. Utilising idiosyncratically chosen pictorial stimuli, Roelofs, Peters, Fassaert, and Vlaeyen (2005) found both chronic back pain and healthy control participants to display

difficulty disengaging from images depicting threat to the back; an effect that was significantly greater in patients. Implementing health catastrophe words (i.e. *ambulance, paralyzed*), Asmundson, Wright, and Hadjistavropoulos (2005) found no significant differences in bias between chronic pain and healthy control participants. However, an overall difficulty disengaging from health catastrophe words was observed when the results from both groups were combined. In a re-analysis of this data, Asmundson and Hadjistavropoulos (2007) provided evidence that individuals with high fear of pain (all of whom were chronic pain patients) may bias towards all forms of threat, including health-catastrophe words. Overall, the results from these investigations suggest information portraying a threat to health may capture attention in individuals with chronic pain and healthy controls, and may be driven by fear of pain. Limitations with these studies are notable however (see Chapter 3 for a detailed discussion of the studies and their limitations), and further research is warranted to address whether individuals with chronic headache demonstrate attentional biases towards stimuli related to threat to health.

The health-threat stimuli included in the current investigation (e.g. wheelchairs, needles, ambulances) all portray a sense of illness and/or deterioration of health. Primary chronic headaches, the focus of the current programme of research, are characterised in part by unknown etiology (Headache Classification Subcommittee of the International Headache Society, 2004). Due to unknown cause, fear and worry concerning potential health outcomes may be particularly high within such individuals. During the course of both Experiments 1 and 2, a number of individuals with chronic headache indicated the unknown source of their pain to be a cause of great concern, with potential negative health outcomes a particular worry. Specifically, it was feared that neurological investigation may have failed to detect something important (i.e. a tumour), and as a consequence future medical intervention, including surgery, would possibly be necessary. While the majority of empirical investigations into such fears have been conducted with musculoskeletal pain patients, research has highlighted elevated fear of pain in chronic headache patients (Hursey & Jacks, 1992). More recently, research has highlighted links between anxiety sensitivity and fear of pain in patients with regular headache (Asmundson, Norton & Veloso, 1999; Norton & Asmundson, 2004), with negative effects upon patient functioning. Such research provides further support for the

need to investigate whether individuals with chronic headache bias attention towards health-threat information, and whether such biases are moderated by fear of pain.

A final area of importance regarding bias specificity concerns bias towards general threat. Evolutionary accounts propose that mammals automatically scan their environment for sources of danger or harm (Öhman, Flykt & Esteves, 2001). As such, bias towards stimuli depicting general threat should not theoretically differ between individuals with chronic headache and healthy controls. The results from Experiment 2 provide some support for this notion, suggesting individuals with chronic pain do not display significant bias towards interpersonal depictions of threat (i.e. angry and sad faces) compared to healthy controls. Despite these findings, it is premature to conclude that these two groups do not differ in their attentional patterns towards *all* forms of non-pain related threat. Former research investigating bias towards general threat in chronic pain has once again been limited. In an uncontrolled investigation, Dehghani, Sharpe and Nicholas (2003) found no significant bias towards threat-related words (e.g. *frightful, danger, and threat*) relative to other word categories (sensory pain, affective pain, and disability-related). Utilising the same stimuli set in uncontrolled investigations, Dehghani, Sharpe and Nicholas (2004) failed to find evidence of bias towards threat-related words, although Sharpe, Dear and Schreiber (2009) found evidence for significant avoidance of such stimuli in a sample of patients with rheumatoid arthritis (again, see Chapter 3 for a more in-depth discussion of these studies and their limitations). The current investigation adopted a category of general-threat related stimuli, which included images depicting both natural and man-made sources of danger, including fire, guns and vehicular accidents. While such depictions obviously have painful connotations, they are labelled as ‘general-threat’ due to the assumption that they are, a) equally relevant to all participants regardless of chronic pain status, and b) not directly related to the experience of chronic pain or chronic headache.

The majority of former studies investigating threat-specificity bias in chronic pain have utilised linguistic stimuli and found no statistical support for differences in bias between chronic pain and healthy control groups. Specifically, Asmundson, Kuperos, and Norton (1997) found no differences with injury-related words; Roloefs et al. (2005) with movement, injury, or social threat words; and Asmundson, Wright et al. (2005) with health catastrophe words. While such findings may be taken as evidence that chronic pain and healthy control groups do not differ in their patterns of bias

towards alternative forms of threat (i.e. threat not directly related to sensory or affective dimensions of pain), a second possibility is that words are not salient enough to elicit such biases. Considering this, the current experiment adopted pictorial stimuli in the form of full-colour images. A second potential explanation for the general lack of alternative-threat biases in chronic pain may be that all former investigations have investigated bias in regards to initial orienting of attention. However, the general lack of evidence for group differences at this stage of attention does not mean that differences do not exist at other stages of attention. Following on from Experiments 1 and 2, the current investigation therefore adopted stimuli presentation times corresponding to both initial orienting of attention (500ms) and maintained attention (1250ms).

Underlying correlates of attentional bias in chronic pain have been frequently explored, although little consistent evidence has been found. Further exploration is warranted, as reliable predictors of attentional bias may themselves be targets for clinical intervention. The current experiment therefore included a number of variables previously unexplored. To date, no former investigation has examined whether the tendency to ruminate over stimulus meaning may underlie attentional bias. Wells and Matthews (1996) have argued rumination to be particularly problematic in emotional disorders, which “reduces thresholds for intrusion of congruent information into consciousness” (p. 882). Patients with chronic pain have often been reported to ruminate and worry about their condition, which in turn may lead to negative effects upon attention. For example, Eccleston, Crombez, Aldrich and Stannard (2001) reported pain-related worries to be more commonly experienced than non-pain worries in a sample of chronic pain patients. Pain-related worries were also reported to be significantly more attention-grabbing, distracting and difficult to dismiss than non-pain related worries. Furthermore, an understanding of the tendency to ruminate, and its relationship to patterns of attentional bias, is warranted as biases during maintained attention, which have been found in a previous investigation (Lioffi et al., 2009) and Experiment 1, have been proposed to reflect attentional dwelling or rumination (Wisco, 2009). It should be noted, however, that an important distinction can be made between rumination and reflection. While both are considered forms of self-attention, the former is motivated by perceptions of loss or injustice, while the latter is motivated by a curiosity in the self (Trapnell & Campbell, 1999). Rumination and reflection can therefore be considered negative and positive forms of self-attention respectively.

Hypervigilance for pain involves a continued scanning of the body for somatic and painful sensations (Chapman, 1978). Such behaviour has been found in individuals with chronic pain, which is particularly elevated in individuals with high fear of pain (Peters, Vlaeyen, & Kunnen, 2002). Despite increased research into chronic pain attentional bias, no former research has investigated whether bias for sensory pain is related to bias for pain-related information. This is an important consideration, as both behaviours may be considered maladaptive if engaged in excessively, and therefore evidence of a relationship between the two may be of clinical importance. However, the visual-probe task is considered an objective measure of attentional processing, and it has been argued that cognitive paradigms such as this are likely to measure processes inaccessible by questionnaire measures (Pincus & Morley, 2001). The current investigation therefore examined the relationship between these two forms of bias, considering whether bias measured objectively via a response-time task correlates with subjective reports of vigilance for physical pain.

#### *Aims and Hypotheses*

The primary aims of this experiment were to investigate the specificity and time-course of attentional bias in individuals with chronic headache. It was examined whether individuals with chronic headache demonstrate bias towards headache, pain, health-threat and general threat images, relative to both healthy, pain-free control participants and 0, at presentation times associated with initial orienting of attention and maintained attention. Based upon theoretical models of attention and pain, and the results of previous investigations, the following hypotheses were adopted:

1. Chronic headache participants will show a significant attentional bias towards headache images only, compared to both healthy controls and comparisons to 0
2. Fear of pain will significantly correlate with bias towards health-threat images in chronic headache participants
3. Rumination and pain vigilance will significantly correlate with bias towards headache and pain images respectively in chronic headache participants

### 6.3. Method

#### *Participants*

Participant recruitment strategies and inclusion and exclusion criteria are as specified in the General Methods section of this thesis. An a priori power analysis indicated greater than 90% power to detect differences of magnitude 0.4 between groups for a sample size of 68 [(effect size = 0.40, Critical F (1, 66)= 3.99, Lambda= 10.88; GPower (Erdfelder et al., 1996)]. Based upon this, a total of 75 individuals (mean age, 43.53 *SD*, 17.04; range 18 to 69 years,) participated in this experiment, including 37 participants meeting the diagnostic criteria for chronic headache (mean age, 44.41; *SD*, 16.84; range, 18 to 68 years) and 38 pain-free, healthy control participants (mean age, 42.68; *SD*, 17.41; range, 19 to 69 years). The majority of participants were female (53; 70.67%). Chronic headache participants reported living with chronic headache for a mean duration of 18.36 years (*SD* 14.62, range 16 months to 50 years), with the majority (29; 78.4%) experiencing one headache per day. Twenty-one (56.8%) participants indicated severe disability as a consequence of their headaches, as indexed by their MIDAS scores. Twenty-eight (75.7%) reported at least one relative to also suffer from headache. Eighteen (48.6%) of the chronic headache participants were suffering from tension headache, 18 (48.6%) from migraine, and 1 (2.7%) from a diagnosis of concurrent chronic migraine and chronic tension type headache. All but one (97.3%) were taking some form of medication in response to their headaches, with 27 (73%) reporting the use of prescription medication (including amitriptyline, sumatriptan, nortriptyline, propranolol, modafinil, atenolol, rizatriptan, zomatriptan, pizotifen, almotriptan, gabapentin, tramadol, liquid morphine, prochlorperazine, buprenorphine, dihydrocodeine, carbamazepine, norotriptyline), and 26 (70.03%) reporting the use of over-the-counter medication (including aspirin, paracetamol, non-steroidal anti-inflammatory drugs, and combinations of paracetamol with other ingredients, including codeine phosphate, doxylamine succinate and caffeine). Based upon the adopted criteria, 5 participants with frequent headaches (i.e. 7 – 10 days per month), were excluded from this investigation who did not meet diagnostic criteria for chronic headache, 1 (chronic headache) due to the presence of another chronic pain condition (i.e. fibromyalgia), 2 (chronic headache) due to the presence of a psychiatric disorder, and 11 (3 chronic headache, 8 healthy) due to being over 70 years of age.

Further to the above, a local neurologist working at Southampton General Hospital with an interest in chronic headache agreed to assist with participant recruitment at the beginning of the investigation. However, this neurologist subsequently left the country and, as no remaining neurologists specialised in headache disorders, no patient referrals were made from the National Health Service (NHS) for this investigation. However, all community-recruited participants had been diagnosed as suffering from chronic daily headache in the past by their GP or a specialist neurologist.

### *Measures*

The questionnaire measures discussed in the General Methods section were included in the current investigation. Further to these, the following were newly adopted:

- The Rumination-Reflection Questionnaire (RRQ; Trapnell & Campbell, 1999) is a 24-item questionnaire providing a measure of two independent forms of self-attention; rumination, which is motivated by perceptions of loss or injustice, and reflection, which is motivated by a curiosity in the self. Trapnell and Campbell (1999) reported high levels of internal consistency for both rumination ( $r = .90$ ) and reflection ( $r = .91$ ) scales. Minimal correlation between the two scales was also reported ( $r = .22$ ).
- The Pain Vigilance and Awareness Questionnaire (PVAQ; McCracken, 1997) is a 16-item questionnaire designed to measure an individual's attention towards pain, and has been commonly used with chronic pain patients (e.g. Roelofs, Peters, McCracken, & Vlaeyen, 2003; Moss-Morris, Humphrey, Johnson, & Petrie, 2007). Evaluation with a sample of chronic back pain patients revealed high levels of both internal consistency ( $r = .86$ ) and test-retest reliability ( $r = .80$ ; McCracken, 1997).

### *Experimental Stimuli*

As discussed below, the visual-probe task was split into two parts (Task A and Task B), both of which included three image pair conditions. All images across both Tasks were resized to 74.79mm wide x 70.56mm high (250 x 265 pixels respectively),

and all image pairs were matched for brightness. Task A featured images of facial expressions, including headache/neutral, pain/neutral and neutral/neutral stimuli conditions (see Figure 6.1). Headache stimuli included those previously used in Experiment 1, featuring a total of 5 female and 3 male models depicting the experience of a headache; a facial expression of pain and hand/s placed upon the temples or forehead. Pain/neutral stimuli were derived from the Montréal Pain and Affective Face Clips (MPAFC; Simon, Craig, Gosselin, Belin, & Rainville, 2008), which are one-second video clips of models depicting facial expressions of pain. In order to extrapolate still images, each video clip was paused at the moment each expression was deemed to be at its most intense. Copies of these paused clips were then converted into images, with the final stimuli set featuring a total of 4 male and 4 female models. Within Task A of the visual probe task, each headache and pain image was paired with a neutral image, featuring the same model with an emotionless expression. In addition, a series of neutral/neutral control images were also included. These images were also included in Experiment 1, and featured the same model depicting two similar emotionless expressions.

Task B featured images of scenes and objects, including health-threat, general-threat, and neutral/neutral conditions (see Figure 6.2). Health-threat images were collected from an online image database, and were chosen to represent potential or actual medical consequences of chronic headache. These images included a wheelchair (paired with an office chair), crutches (paired with chopsticks matched for size), a needle (paired with a pen), an ambulance (paired with a white van), hospital beds (paired with hotel beds), medical utensils (paired with kitchen utensils), medical pills (paired with stones), and an ambulance with stretcher (paired with a van and mattress). The general-threat images were collected from an online image database and the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 2008) (image numbers 6570, 6570.2, 9635.1, 9635.2, and 9622). This stimuli set was chosen to reflect both natural and man-made sources of danger, and included a gun to the head (paired with hairdryer to the head), a man on fire (paired with a barrel on fire), a vicious dog (paired with a tame dog), an exploding plane (paired with a flying plane), a sinking ship (paired with a sailing ship), a burning house (paired with a non-burning house), a window with erupting fire (paired with a non-burning window), and a crushed car (paired with an undamaged car).

Within both health- and general threat conditions, each threatening image was matched with a neutral image. As indicated, in some cases this involved the same object in a non-threatening depiction (e.g. an exploding plane vs. a non-exploding plane), or a different object matched for colour, size and orientation (e.g. a wheelchair vs. an office chair). Finally, a neutral/neutral control condition was also included, featuring images either taken from the online database of photographed by the researcher. Pairs of neutral objects were used in this condition, including boats, trucks, stationary, chairs, keys, plates, and brushes. All images were similar, but not identical, and were once again matched for size, colour, and orientation.



Headache stimulus



Neutral headache counterpart stimulus



Pain stimulus



Neutral pain counterpart stimulus

Figure 6.1. Example of headache-related and pain-related stimuli included in Task A of the visual-probe task (pain images are adapted from the MPAFC [Simon et al. 2008])



Health-threat stimulus



Neutral health-threat counterpart stimulus



General-threat stimulus



Neutral general-threat counterpart stimulus

Figure 6.2. Example of health threat-related and general-threat stimuli included in Task B of the visual-probe task (general-threat images are taken from the IAPS [Lang et al. 2008], image numbers 6570 & 6570.2)

Prior to inclusion in the experimental Tasks, a preliminary analysis of the valence and arousal of the experimental stimuli was conducted with a computerised version of the Self Assessment Manikin (SAM; Lang, 1980). Ten independent participants (5 male, 5 female, mean age 25.70; *SD*. 3.34), rated a large set of images, including those finally included in the current investigation. All images were randomly presented to participants for 3 seconds each. Following this, two 9-point SAM scales were presented, including one for valence and one for arousal. Participants were instructed to indicate how happy and aroused they felt whilst viewing each image, using the computer mouse to provide their responses on the valence and arousal SAM scales respectively. A total of 10 participants (5 male, 5 female) completed this rating task (mean age 25.70; *SD*. 3.34). The stimuli set included in the current investigation were selected based upon the ratings provided. The results for this final stimulus set are presented in Table 6.1.

Table 6.1

*Mean (SD) valence and arousal of experimental and control stimuli used in the visual-probe task*

Image condition	Valence	Arousal
Headache	4.13 (.35)	3.50 (.76)
Pain	4.13 (.35)	3.38 (.74)
Health-threat	4.13 (.64)	3.25 (.46)
General-threat	2.88 (.35)	5.00 (.54)
Headache neutral	4.75 (.46)	3.00 (.54)
Pain neutral	5.00 (.00)	3.00 (.00)
Health-threat neutral	5.13 (.35)	2.88 (.35)
General-threat neutral	5.13 (.64)	3.38 (.52)
Neutral faces (control)	5.06 (.25)	2.94 (.25)
Neutral scenes and objects (control)	5.06 (.25)	2.81 (.40)

A Bonferroni correction for multiple comparisons was applied, with an accepted alpha of .003 adopted. For stimuli in Task A, pain images were rated as significantly less pleasant than their neutral counterparts ( $t(7) = 7.00, p < .001$ ). For Task B, general-threat images were significantly less pleasant ( $t(7) = 13.75, p < .001$ ), and significantly more arousing ( $t(7) = 8.88, p < .001$ ), than their neutral counterparts. In addition all experimental images were compared with each other. For Task A, no significant differences in either valence or arousal were found between headache and pain images. Within Task B however, general threat images were rated as less pleasant ( $t(7) = 5.00, p = .002$ ) and more arousing ( $t(7) = 5.58, p = .001$ ) than health threat images. General threat images were also less pleasant than headache ( $t(7) = 7.64, p < .001$ ) and pain ( $t(7) = 7.64, p < .001$ ) images, and more arousing than pain images ( $t(7) = 6.18, p < .001$ ). No other significant differences between image groups were found.

#### *Visual-Probe Task*

For this experiment, two separate visual-probe programmes were developed within the Presentation® software (version 12.2, [www.neurobs.com](http://www.neurobs.com)), which were run on an IBM compatible personal computer with a 15-inch colour monitor. The decision to include two separate tasks ensured that participants took a mandatory break, which also allowed the researcher to verify the participant was feeling well to continue. Due to the length of the task, this was deemed especially necessary for participants with chronic headache. In order to ease programming requirements (i.e. in regards to randomisation of stimuli presentation) and ensure conceptual homogeneity within a task, a subsequent decision was made to separate the tasks into one featuring facial expressions only (Task A), and one featuring objects and scenes only (Task B). Each task featured 192 experimental trials, which were presented in a new randomised order for each participant. Each task began with 12 practice trials, followed by 96 experimental trials. A break was provided at this halfway point, with the second half beginning with 2 buffer trials (for participants to re-familiarise themselves with the task) followed immediately by the remaining 96 experimental trials. Tasks A and B both took approximately 12 minutes to complete. An additional break was provided between these two Tasks, with the entire procedure lasting approximately 24 minutes minus the break.

Visual-probe specifics were similar to those described in Experiment 2. Specifically, each trial began with a fixation cross in the centre of the screen for 500ms. Following this, a randomly selected image-pair was presented horizontally (i.e. one image to the left of this initial fixation cross, the other to the right) for either 500ms or 1250ms. The distance between the inner edges of the two images was 36mm. Immediately following the disappearance of this image-pair, a visual-probe was randomly displayed in either to left or right location, replacing one of the former images. Participants were required to indicate the location of this probe as quickly as possible, using a two-button response-box (with 'L' and 'R' labels for left and right respectively) to indicate their response. Following a randomly determined inter-trial interval of either 1000 or 1500ms, the next trial began with the display of the initial fixation cross. Participants were seated approximately 60cm from the monitor, and therefore the visual angle of stimuli in this experiment was 6.7°.

### *Procedure*

The procedure is as specified in the General Method section of this thesis, with two exceptions. Firstly, ethical approval was also obtained from the Isle of Wight, Portsmouth & South East Hampshire NHS Research Ethics Committee. Secondly, participants completed two separate visual-probe tasks. The order of these tasks was randomised for each participant. After the first task, the researcher came into the room and set up the second task, during which time the participant was afforded a break. The experimental duration lasted approximately 60 minutes.

## **6.4. Results**

### *Data Reduction and Analytic Plan*

All results were analysed in PASW Statistics 18.0 for Windows. Buffer and practice trials were excluded from final analysis, along with any incorrect responses. Box and whisker plots for overall data revealed outliers to be any response latencies falling below 200ms or above 1000ms, which were removed. Following this, mean

response times were calculated for each participant, with responses more than 3 standard deviations away from this mean also removed as outliers. Bias indices were calculated from the raw data in the same manner utilised in Experiment 1. Differences in demographic characteristics between groups were explored with  $\chi^2$  and t-tests for categorical and continuous variables respectively. A  $2 \times 2 \times 4$  analysis of variance (ANOVA) of attentional bias scores was carried out with group (headache, control) as a between-subjects independent variable (IV), and exposure duration (500, 1250 ms) and image type (pain, headache, health-threat, general threat) as within-subject IVs. ANOVA and t-tests were also used in post-hoc analyses to clarify significant main effects and interactions.

Pearson's correlation coefficients were calculated between the attentional bias scores at both exposure durations with the self-report measures and headache chronicity. The internal consistency of the self-report measures and their subscales were calculated with the use of Cronbach's alpha (Appendix D). Based upon the commonly used cut off of .70 (Christmann & Aelst, 2006), the following were not included in the correlational analysis; the externally orientated thinking subscale of the TAS-20, the praying and hoping subscale of the CSQ, the affective pain subscale of the MPQ-SF, and the MBSS. For ANOVA analyses, alpha level was set at .05, two-tailed. Alpha was set at .01 for correlation coefficients due to the large number of calculations made.

### *Group Characteristics*

To assess group equivalences, independent samples t-tests were performed on *headache frequency* and *age* variables, while a chi-square analysis was conducted on the variable of *gender*. As shown in Table 6.2, no significant differences between chronic headache and healthy control groups were found for either *age* or *gender* although, as expected, significantly more headache days per month were reported by the first group.

Table 6.2

*Group equivalence results (SD) for demographic variables and headache frequency*

Variable	Headache group ( <i>n</i> = 37)	Healthy group ( <i>n</i> = 38)	<i>t</i> / value	<i>df</i>	<i>p</i>
Headache frequency (Days per month)	24.08 (6.89)	1.37 (1.32)	19.71	38.59	.001
Gender (% female)	26 female (70.3%)	27 female (71.05%)	.006	1	.941
Age (in years)	44.41 (16.84)	42.68 (17.41)	.44	73	.665

### *Self-Report Measures*

The mean self-report data for measures completed by both chronic headache and healthy control participants are displayed in Table 6.3. A series of independent t-tests were conducted on measures administered to both groups. A Bonferroni correction for multiple comparisons was applied, with an accepted alpha of .004 adopted. Chronic headache participants reported significantly higher levels of depression (HADS;  $p < .001$ ) and alexithymia (TAS-20;  $p = .002$ ) than healthy controls, with heightened scores upon the difficulty identifying feelings ( $p = .004$ ) and externally orientated thinking ( $p = .003$ ) subscales of the TAS-20. Chronic headache participants also completed additional questionnaires detailing their headache experiences, the results of which are displayed in Table 6.4.

Table 6.3

*Comparison of mean (SD) self-report scores for chronic headache and healthy control participants*

Measure	Headache group ( <i>n</i> = 37)	Healthy group ( <i>n</i> = 38)	Mean difference	<i>t</i>	<i>df</i>	<i>p</i>
ASI	23.14 (11.85)	18.79 (10.90)	4.35	1.65	73	.103
MBSS sum	6.51 (4.85)	6.08 (3.24)	.44	.46	73	.649
STAI state	32.51 (8.64)	30.95 (9.27)	1.57	.77	73	.452
STAI trait	40.41 (10.86)	35.76 (9.79)	4.64	1.95	73	.056
TAS-20 total	50.54 (11.74)	42.24 (10.67)	8.30	3.21	73	.002
TAS-20 - DIE	18.19 (6.73)	14.00 (5.27)	4.19	3.01	73	.004
TAS-20 - DDE	12.43 (4.51)	11.05 (3.85)	1.38	1.43	73	.158
TAS-20 – EOT	19.92 (3.98)	17.18 (3.86)	2.74	3.02	73	.003
HADS anxiety	7.38 (3.89)	6.16 (2.49)	1.22	1.61	60.98	.112
HADS depression	4.92 (3.02)	2.58 (2.00)	2.34	3.95	62.15	.001
RRQ rumination	39.78 (10.23)	38.66 (8.88)	1.13	.51	73	.612
RRQ reflection	34.03 (8.66)	39.63 (9.35)	5.61	-2.69	73	.009

Note: ASI = Anxiety Sensitivity Index; MBSS = Miller Behavioral Style Scale; STAI = State Trait Anxiety Inventory; TAS = Toronto Alexithymia Scale (DIE = difficulty identifying emotions; DDE = difficulty describing emotions; EOT = externally-oriented thinking); HADS = Hospital Anxiety and Depression Scale; RRQ = Rumination-Reflection Questionnaire

Table 6.4.

*Mean (SD) self-report scores for pain measures completed by chronic headache participants*

Measure	Headache group ( <i>n</i> = 37)
CPAQ Total	63.65 (17.84)
CPAQ willingness	27.11 (11.18)
CPAQ activities	36.54 (10.60)
Dividing attention	9.11 (6.78)
CSQ	
Reinterpretation	6.43 (7.12)
CSQ	
Catastrophising CSQ	12.70 (6.81)
Ignoring CSQ	13.38 (8.75)
Praying CSQ	9.81 (6.10)
Coping CSQ	20.62 (7.95)
IBA CSQ	13.68 (7.85)
Control CSQ	2.75 (1.40)
Decrease CSQ	2.43 (1.28)
MPQ sensory	15.27 (6.69)
MPQ affective	5.11 (2.83)
MPQ Total (sensory + affective)	20.30 (8.92)
MPQ current pain	44.76 (31.2)
MPQ overall pain	3.11 (1.22)
PSEQ	34.32 (13.25)
PVAQ	45.68 (10.27)

Note: CPAQ = Chronic Pain Acceptance Questionnaire; CSQ = Pain Coping Strategies Questionnaire; MPQ-SF = McGill Pain Questionnaire- short form; PSEQ = Pain Self Efficacy Questionnaire; PVAQ = Pain Vigilance and Awareness Questionnaire

The means for the indices of attentional bias at both presentation times are presented in Table 6.5. Depression and alexithymia were not included as covariates in the ANOVA analyses as, 1) no significant correlations were found between these variables and any of the bias indices, 2) for depression, Levene's test for homogeneity revealed unequal variances between chronic headache and control groups ( $F = 4.25, p = .043$ ).

Table 6.5.

*Mean bias index response scores (SD) for chronic headache (n= 37) and healthy control (n= 38) participants*

	Headache group		Healthy group	
	500ms	1250ms	500ms	1250ms
Headache index	10.68 (32.42)	13.44 (28.45)	5.04 (21.11)	-5.12 (24.47)
Pain index	9.63 (26.00)	-4.27 (25.61)	2.35 (23.80)	1.94 (23.78)
Health-threat index	-2.02 (20.31)	-5.51 (33.94)	4.30 (22.86)	.96 (27.88)
General-threat index	6.84 (26.47)	7.25 (27.35)	19.82 (30.58)	6.13 (23.10)

#### *Visual-Probe Analysis*

The two groups did not differ significantly in the amount of RT data lost due to errors ( $M = 0.87\%, SD = 0.93$ ) or outliers ( $M = 1.8\%, SD = .94$ ), or in overall mean RT ( $M = 594.72\text{ms}, SD = 83.48$ ).

A 2 (*group*; headache vs. healthy) x 2 (*time*; 500 ms vs. 1250 ms) x 4 (*image*; pain vs. headache vs. health threat vs. general threat) mixed ANOVA was calculated on participant attentional bias scores. Significant main effects of *image*,  $F(3, 219) = 4.97, p = .002, \eta_p^2 = .064$ , and *presentation time*,  $F(1, 73) = 4.54, p = .037, \eta_p^2 = .059$ , were

found. No main effect of *group* was found,  $F(1, 73) = .001, p = .978$ . Post-hoc analysis was conducted to clarify the main effects. Considering the effect of *image*, participants showed significantly greater bias towards general threat images compared to both pain ( $MD 7.60ms, p = .049$ ) and health threat ( $MD 10.58, p = .001$ ) images. Considering the effect of *time*, participants demonstrated significantly greater bias towards threatening stimuli presented for 500 than 1250ms ( $MD 5.23, p = .037$ ). A significant *image* x *group* x *presentation time* interaction was found,  $F(3, 219) = 3.01, p = .031, \eta_p^2 = .040$ . A significant *image* x *group* interaction was found,  $F(3, 73) = 4.42, p = .005, \eta_p^2 = .057$ , whilst *presentation time* x *group*,  $F(1, 74) = .464, p = .498$ , and *presentation time* x *image*,  $F(3, 222) = .271, p = .846$  were non-significant.

In order to clarify the significant interactions, four separate 2 (*group*; headache vs. healthy) x 2 (*time*; 500 ms vs. 1250 ms) ANOVAs were conducted with the bias indices. For headache images, a significant effect of *group*,  $F(1, 73) = 6.85, p = .011, \eta_p^2 = .086$ , was found. Examination of means revealed significantly greater bias in chronic headache participants compared to healthy controls (mean difference = 12.04). No significant results with pain, health-threat, or general-threat images were found via these 2 x 2 ANOVAs.

Further to the above, separate 2 (*group*; headache vs. healthy) x 4 (*image*; headache, pain, health-threat, general-threat) ANOVAs were conducted for 500ms and 1250ms conditions. With 500ms bias data, a significant effect of *image*,  $F(3, 219) = 3.70, p = .013, \eta_p^2 = .048$  was found, along with an *image* x *group* interaction,  $F(3, 219) = 3.43, p = .018, \eta_p^2 = .045$ . Pairwise comparisons revealed significantly greater bias towards general-threat images compared to health-threat images ( $MD 12.19, p = .002$ ). Considering the significant interaction, evidence showed healthy controls to demonstrate greater bias towards general-threat images compared to chronic headache participants, which approached significance,  $t(73) = 1.96, p = .054$ . With 1250ms bias data, a significant *image* x *group* interaction was found,  $F(3, 219) = 4.05, p = .008, \eta_p^2 = .053$ . Independent t-tests revealed chronic headache participants to demonstrate significantly greater bias towards headache images compared to healthy controls,  $t(73) = 3.03, p = .003$ .

### *Comparisons to 0*

Attentional bias indices were compared to 0, which theoretically equates to no attentional preference either towards or away from the headache stimuli. For the chronic headache group, significant bias was found towards headache images at both 500ms ( $MD$  10.68ms,  $SD$  32.42,  $t(36) = 2.00$ ,  $p = .05$ ) and 1250ms ( $MD$  13.44ms,  $SD$  28.45,  $t(36) = 2.87$ ,  $p = .007$ ), and pain images at 500ms ( $MD$  9.63,  $SD$  26.60,  $t(36) = 2.20$ ,  $p = .034$ ). For the healthy control group, significant bias was found towards general threat images presented for 500ms (19.87ms,  $SD$  30.58,  $t(37) = 4.00$ ,  $p = .001$ ). Averaged across both groups, significant bias was found towards headache images at 500ms ( $MD$  7.82ms,  $SD = 27.24$ ,  $t(74) = 2.49$ ,  $p = .015$ ), pain images at 500ms ( $MD$  5.94ms,  $SD = 25.32$ ,  $t(74) = 2.03$ ,  $p = .046$ ), and general threat images at both 500ms ( $MD$  13.42ms,  $SD = 29.17$ ,  $t(74) = 3.98$ ,  $p = .001$ ) and 1250ms ( $MD$  6.68ms,  $SD = 25.12$ ,  $t(74) = 2.30$ ,  $p = .024$ ). Individual 95% confidence intervals for all image groups across both participant groups are shown in Figure 6.3.

### *Correlations between Indices of Attention and Self-Report Measures*

Correlations between the various self-report measures and the indices of attentional bias were computed, with the alpha level adjusted to  $p < .01$  due to the high number of calculations. The full correlation matrices can be found in Appendix D. No significant correlations were found for the chronic headache group. For the healthy control group, state anxiety (measured via STAI) was positively correlated with the *pain* bias index at 500ms,  $r = .441$ ,  $p = .006$ , and the *general* bias index at 1250ms,  $r = .415$ ,  $p = .010$ . Rumination (measured via RRQ) was positively correlated with *general* bias at 500ms,  $r = .434$ ,  $p = .006$ . In addition to separate group analyses, all participants were included together in an overall correlational analysis ( $N = 75$ ). *Pain* bias at 500ms was positively correlated with both state anxiety (measured via the STAI),  $r = .423$ ,  $p < .001$ , and trait anxiety as measured via the STAI,  $r = .305$ ,  $p = .008$ , and the HADS,  $r = .313$ ,  $p = .006$ .

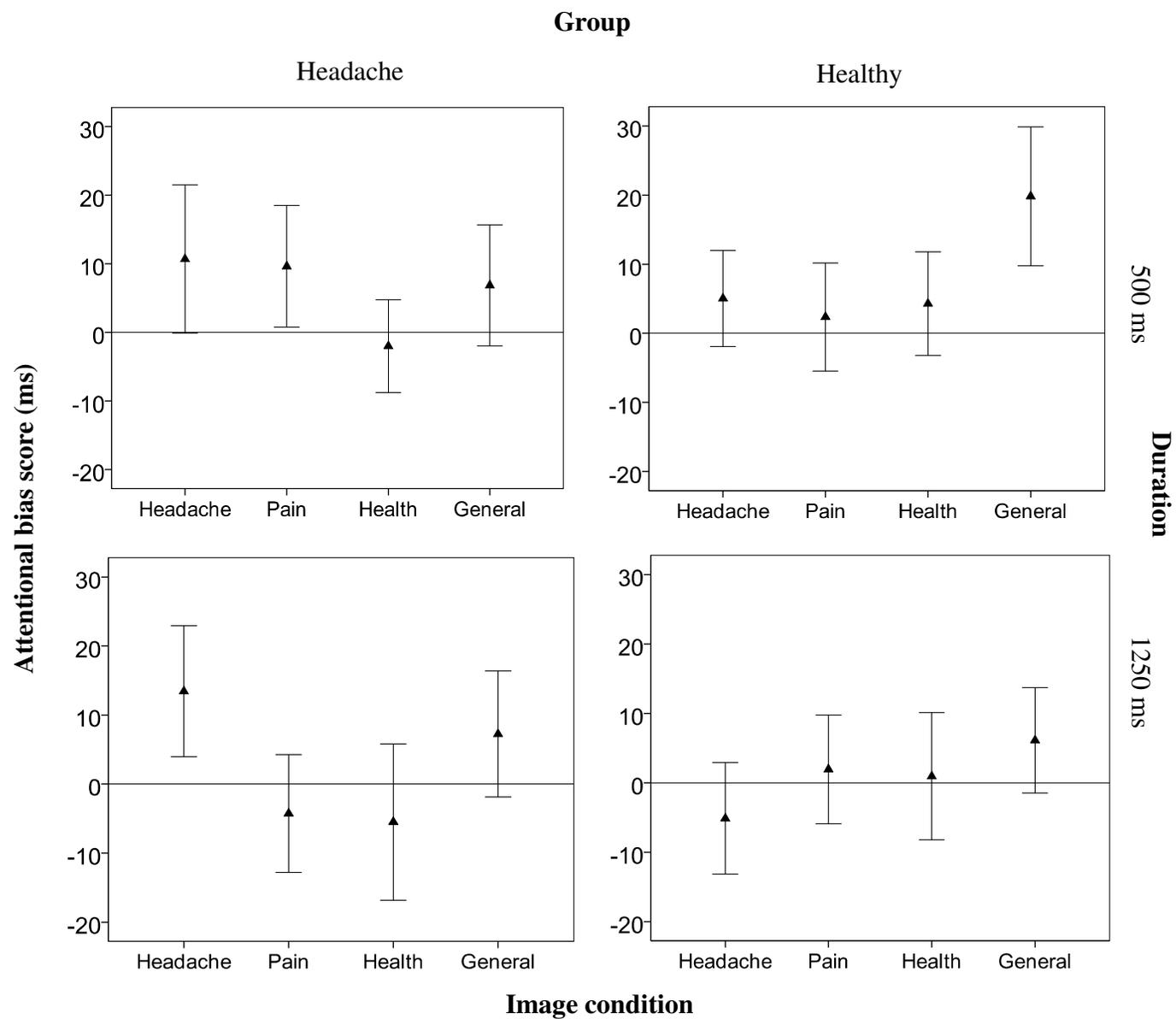


Figure 6. 3. 95% confidence interval error bars for mean attentional bias scores across all image conditions for headache and healthy groups

## 6.5. Discussion

The aim of the current experiment was to investigate the specificity and time-course of attentional bias in individuals with chronic headache, utilising a visual-probe task with headache, pain, health-threat and general-threat pictorial stimuli. Supporting the first experimental hypothesis, individuals with chronic headache demonstrated a significant bias towards headache images compared to healthy controls. Post-hoc analysis revealed this bias to be significant for images presented at 1250ms only, therefore replicating the results of Lioffi et al. (2009). When compared to 0, the chronic headache group demonstrated significant bias towards headache images at both 500 and 1250ms. Contrary to the second hypothesis, no significant correlations were found between fear of pain (measured via the ASI) and bias towards health-threat images. Indeed, overall there was no evidence of any bias towards this group of stimuli. The third hypothesis was also unsupported, as no significant correlations were found between rumination and bias towards headache images, and pain vigilance and bias towards pain images. Overall, these results add to the growing number of studies which support the presence of disorder-relevant attentional biases in individuals with chronic headache.

In line with theories of emotional processing (e.g. Wells and Matthews, 1994; 1996, Bower, 1981) individuals with chronic headache, compared to healthy controls, showed significantly greater bias towards headache-related information only, and not towards pain-related, health-threat, or general-threat information. The results from an increasing number of studies have therefore demonstrated stimuli specificity to be an important aspect of attentional bias in chronic headache. The current results may therefore be indicative of dominant, disorder-related schemata in the chronic headache group, which favours the processing of relevant headache information. Although headache- and pain-related images all featured facial expressions of pain, the headache information conveyed in the former appear to be especially salient for individuals with chronic headache. This finding therefore has implications for theoretical models of attention and pain (e.g. Pincus & Morley, 2001; Van Damme, Legrain, Vogt, & Crombez, 2010), which although predict bias towards pain-related information and cues, do not explicitly address the specificity of pain-information.

The lack of group differences with facial expressions of pain deserves further consideration. Such expressions are likely to serve multiple social functions, whereby communication of pain may elicit help from other individuals. Additionally, such expressions may also be of adaptive value to others, providing a warning of danger in the environment (Williams, 2002). As such, all individuals may be evolutionary primed to bias attention towards painful expressions, explaining the lack of between-group differences. The current investigation, however, provides little support for this notion, with the exception that, when compared to 0, the chronic headache group demonstrated significant bias towards painful expressions during initial orienting. Although this result was also found with data from both groups combined, this was driven by the chronic headache group, as the healthy control group alone showed no significant bias. Aside from the current investigation, little research has investigated bias towards painful expression, which is surprising given the evolutionary functions noted. Khatibi et al. (2009), found evidence of significant avoidance of painful expressions in healthy controls and chronic pain patients with low fear of pain. In contrast, only patients with high fear of pain demonstrated significant bias *towards* such expressions. Some discrepancy is therefore noted between these results and those of the current investigation, with further research necessary in both chronic pain patients and healthy controls.

Further to exploring specificity of bias, an additional aim of the current investigation was to provide further information concerning the time-course of bias. As noted, chronic headache participants, compared to healthy controls, demonstrated significantly greater bias towards headache images during maintained attention (i.e. presented for 1250ms). Support is therefore provided for the results of Lioffi et al. (2009), who found the same pattern of bias utilising linguistic word stimuli relevant to headache. The results of Experiment 1, however, found no significant effect of presentation time, instead finding evidence of attentional bias during both initial orienting and maintained attention. In combination, these results suggest that disorder-related stimuli have more robust effects upon maintained attention, and are more likely to elicit bias at this attentional stage. Indeed, supporting this, across all three studies bias at 1250ms was more pronounced than at 500ms. Bias during initial orienting appears less consistent, and is perhaps more likely to be influenced by methodological (e.g. stimuli type) and individual-difference (e.g. depression,

anxiety) variables. As discussed in Chapter 3, such differences may be responsible for the mixed findings in former bias research that have presented pain-related stimuli during stages of initial orienting of attention only.

In addition to between-group analyses, bias scores were also compared to 0. It should be noted, however, that comparison to 0 is likely to be less informative than comparison to healthy controls. Specifically, healthy individuals are unlikely to react with complete neutrality to any form of emotional stimuli, and therefore some level of attentional preference is to be expected. This is evident in the current results, where the healthy control group does not display a bias score of 0 (i.e. equal processing of neutral and experimental images) for any of the displayed stimuli. The main question addressed in this programme of research is whether individuals with chronic pain display biases greater than those typically expected (as indicated by bias in non-pain controls). However, as significant between-group differences may result from one or both groups demonstrating bias, comparisons to 0 offer a method of clarification (Gotlib, Krasnoperova, Yue, & Joormann, 2004; Joormann & Gotlib, 2007). Considering this, the current results showed the chronic headache group to demonstrate significant bias towards headache images at both 500 and 1250ms presentation times. Thus, the current chronic headache sample appeared to initially orientate their visual attention towards disorder-related information, and continue to focus upon this during stages of maintained attention. Considering bias specificity, bias towards pain expressions was also shown during initial orienting of attention. Thus, whilst both facial expressions of pain and headache images capture initial attention in this group, this bias is not maintained in the former. Indeed, the results suggest chronic headache participants then become somewhat avoidant of such stimuli, although this result did not significantly differ from 0. Temporal variation of bias is therefore apparent in individuals with chronic headache when considering these two types of information. It is therefore likely that the increased relevance of the headache stimuli led to this longer attentional capture, possibly reflecting a difficulty in attentional disengagement.

To further explore the specificity of attentional bias, health-threat images were included, which convey information representing poor or deteriorating health. Former research has provided some evidence of bias towards such stimuli (Asmundson, Wright et al., 2005; Asmundson & Hadjistavropoulos, 2007), which

may be stronger in individuals with chronic pain (Roelofs et al., 2005). A positive correlation between fear of pain and bias towards these images was therefore predicted for the chronic headache group. As primary chronic headaches are characterised by unknown etiology (Headache Classification Subcommittee of the International Headache Society, 2004), such images were hypothesised to be relevant to the current chronic pain sample, representing fear of an uncertain future. The lack of support for this prediction was therefore surprising, although may be interpreted in a number of ways. Firstly, it is possible that the images utilised did not fully represent the specific fears held by those with chronic headache. Rather, such images may have reflected more general health-related concerns. Aside from the presence of chronic headache, participants were otherwise healthy (i.e. no comorbid medical conditions), and therefore the images used in this condition may not have contained enough personal relevance to elicit attentional bias. In contrast, the images used by Roelofs et al. (2005), which depicted specific threat to the back, were likely to have been of greater relevance for patients with chronic back pain (although this does not explain why the healthy control group also showed difficulty disengaging). A second possibility is that, as the current sample reported living with chronic headache for an average of 18.36 years, any initial fears that headache pain signified a serious underlying disorder may have reduced over time. However, although pain chronicity varied quite considerably in the current sample (range 16 months to 50 years), analysis found no evidence for any correlations between chronicity and any of the bias indices. In order to clarify this issue, future research would benefit from adopting recorded interview sessions, whereby each participant's individual fears and concerns can be assessed.

To examine whether chronic pain and healthy control groups differ in their biases towards non-pain related threat, general-threat images were included in the current experiment. While the results from Experiment 2 showed no differences between these groups in regards to depictions of interpersonal threat (i.e. angry and sad facial expressions), it was premature to conclude from these results that differences do not exist towards all forms of non-pain related threat. Addressing this, the current results found healthy controls to demonstrate greater bias towards general threat at 500ms compared to chronic headache participants, although only a trend towards statistical significance was found. Supporting this, comparisons to 0

revealed the control group to significantly bias towards such images presented for 500ms. Thus, the current results are suggestive that pain-free individuals are more likely to initially orientate their attention towards general-threat information than individuals with chronic headache. One explanation for this finding may be that, as individuals with chronic headache are preoccupied with disorder-relevant information (as evident by the significant bias towards headache stimuli), they are less concerned with general-threat information, which may be perceived as less relevant to their current situation. Thus, the tendency to initially bias towards generally threatening information may be suppressed in individuals with chronic headache, perhaps as a result of dominant disorder-related schemata. This interpretation should be viewed with caution, however, with further research needed.

Across both groups, bias towards general-threat images was significantly stronger than bias towards pain-related and health-threat images. All individuals may therefore show some bias towards general-threat information (despite stronger bias in healthy controls at stages of initial orienting). Stimuli within this category were designed to reflect threat towards well-being, with all images conveying a sense of imminent danger. In order to survive, it has been argued that mammals must have evolved a series of perceptual processes which scan the environment for sources of danger or harm, and that such processes would be automatic and outside of conscious awareness (Öhman et al., 2001). Evidence of an overall bias towards general-threat stimuli is therefore unsurprising. Evolutionary relevant threat stimuli, including spiders and snakes, have been shown to automatically capture attention (Öhman et al., 2001). The stimuli utilised in the current experiment featured a mixture of both naturalistic and man-made threats, suggesting that automatic bias towards threatening stimuli is not exclusive to evolutionary threats alone. Considerable research has shown similar findings, including investigations into the 'weapon-focus' phenomenon, whereby attention is preferentially focused upon weapons at the cost of other peripheral stimuli (e.g. Loftus, Loftus & Messo, 1987; Pickel, 1998, 1999). Based upon the current findings, the argument is made that bias towards general depictions of threat is common in all individuals, although current concerns may affect the strength of such bias. Related to this finding, it is important to note the main effect of stimulus presentation time, which showed bias towards threat to be significantly stronger when images were presented for 500ms than

1250ms. This finding supports the theoretical notion raised above, as passive, stimulus-driven attentional processes aimed at maintaining survival are argued to bias attention rapidly and automatically towards sources of potential threat (Öhman et al., 2001)

Investigation of individual difference variables revealed a number of significant differences between chronic headache and healthy control participants. Firstly, depression was significantly higher in the former group, a finding that has been reported in the majority of former investigations (Asmundson et al., 1997; Asmundson, Carlton et al., 2005; Asmundson, Wright, et al., 2005; Khatibi et al., 2009; Experiment 2). Additionally, chronic headache participants also reported significantly higher levels of alexithymia, supporting results found by Liossi et al. (2009). Indeed, research in general has often reported high alexithymia levels in chronic pain populations (Lumley, Smith & Longo, 2002). While the experience of chronic pain within the current investigation was therefore linked to increased levels of both depression and alexithymia, neither of these variables were significantly correlated with performance on the visual-probe task, suggesting bias to be independent of these aspects of functioning.

Correlational analysis revealed a number of significant correlations between the bias indices and self-report measures. For the control group, significant correlation was found between state anxiety and bias towards both pain images and general-threat images. However, while the former was found during initial orienting, the latter was found during maintained attention. Although research investigating anxious individuals has more commonly reported evidence for bias during initial orienting (e.g. Bradley, Mogg, Falla & Hamilton, 1998; Mogg & Bradley, 1999; Mogg, Miller & Bradley, 2000b), a recent meta-analysis has suggested bias also exist during presentation times associated with maintained attention (Bar-Haim et al., 2007). The above correlations are therefore both supportive of previous findings, although it remains unknown as to why the correlations differed in regards to time-course. Within the healthy group, a significant correlation was also found between rumination and bias towards general-threat during initial orienting. As rumination reflects the tendency to focus upon distress (Nolen-Hoeksema, 1991), correlation with bias towards images portraying high levels of threat and distress makes sense.

However, it is unknown as to why this correlation was not also found with general-threat stimuli presented for 1250ms.

Across all participants, both state and trait anxiety were positively correlated with attentional bias towards pain images presented for 500ms. These results support those reported by Lioffi et al. (2009), who found a strong correlation between trait anxiety and bias towards pain words at 500ms across all participants. Thus, two investigations have found evidence for a general correlation between anxiety and attention towards pain-related stimuli during initial orienting of attention. This relationship is potentially important, as a number of investigations have provided evidence that individuals with high levels of anxiety perceive pain to be more intense (e.g. James & Hardardottir, 2002; Tang & Gibson, 2005), and exhibit reduced pain tolerance (Carter et al., 2002). The current results also suggest that anxiety may be related to an increased anticipation or worry for pain. Further research into this area would be beneficial, as reductions in anxiety may be linked to reduced pain vigilance. For patients with unmanageable chronic pain, interventions aimed at reducing anxiety may therefore be effective in increasing quality of life.

In order to more fully explore potential underlying correlates of attentional bias in chronic headache, two previously unexplored measures of subjective pain vigilance and rumination were included in the current investigation. However, failing to support the third hypothesis, these variables were not respectively correlated with bias towards pain and headache images in the chronic headache group. Considering pain vigilance, the current results suggest attentional bias to be unrelated to an individual's subjective vigilance for pain signals and symptoms. Pincus and Morley (2001) have argued, however, that while questionnaires measure conscious cognitive processing, experimental paradigms such as the visual probe task measure cognitive processes inaccessible by questionnaires. The lack of significant correlation between the subjective measure of pain vigilance utilised and pain bias is therefore perhaps unsurprising, if indeed different cognitive processes are measured. This may be taken as further evidence for the automatic nature of attentional bias, which the individual may not be consciously aware they possess, or have little control over. The benefits of using paradigms such as the visual-probe task in clinical settings as screening tools for psychological intervention are therefore proposed.

Considering rumination, one possible explanation for the lack of correlation with bias towards headache images is that the self-report measure used (the RRQ) was not specific enough to chronic pain, which measures generalised trait rumination reflecting a neurotic self-consciousness (Trapnell & Campbell, 1999). Once again, however, it is also possible that questionnaire measures simply do not measure the same cognitive processes as the visual-probe task. Regardless of this, it would be beneficial for future research to adopt a specific measure of pain rumination. The Pain Catastrophizing Scale (Sullivan, Bishop, & Pivik, 1995) has a subscale on pain rumination, and has been commonly adopted in clinical research (Van Damme, Crombez, Bijttebier, Goubert, & Van Houdenhove, 2002). Future research investigating the relationship between rumination and attentional bias in chronic pain may therefore benefit from inclusion of this measure, which along with the RRQ would also provide information as to whether general rumination and pain rumination are related.

The current programme of research has provided important information pertaining to the use of pictorial stimuli within the visual-probe task. Questions remain, however, over the use of pictorial stimuli in alternative measures of attentional bias. One such measure, the emotional Stroop task, has also been frequently used to assess attentional bias in chronic pain. Within this body of research, evidence has been found that individuals with chronic pain show significant colour-naming interference on pain-related words; a finding that has been supported by a meta-analysis (Roelofs, Peters, Zeegers & Vlaeyen, 2002). To date, no research with this paradigm has made use of pictorial stimuli. This remains an important area for future research, affording the opportunity to investigate specificity of bias in chronic pain via alternative paradigms to the visual-probe task, which themselves may measure alternative aspects of attention or cognition. Specifically, it has been argued that biases via the emotional Stroop task may reflect more rapid, automatic attentional processes, while those via the visual-probe may reflect more strategic processes associated with later stages of attentional processing (Brosschot, de Ruiter, & Kindt, 1999; Johansson, Ghaderi, & Andersson, 2004).

A number of limitations can be noted with the current investigation. Firstly, the lack of any formal interviews may have hindered the investigation of bias towards health-threat images. As research has demonstrated a relationship between

anxiety sensitivity and fear of pain (Asmundson et al., 1999; Norton & Asmundson, 2004), scores on the ASI were predicted to correlate with bias towards health-threat images. It is possible, however, that the ASI does not measure specific fears regarding future consequences of pain, hence the lack of significant findings. Former research investigating attentional bias in pain samples have not made use of qualitative data from interviews, although this is likely the best method for understanding specific fears held by the those with chronic pain. Related to this, inclusion of a specific measure of health anxiety would have also been beneficial in regards to bias towards health-threat images. As a high prevalence of health anxiety has been reported in chronic pain (e.g. Rode et al., 2006), this remains an important area of investigation for future attentional bias research.

In order to allow comparison of the results to former chronic headache research (Lioffi et al, 2009; Experiment 1; Experiment 2), presentation times of 500 and 1250ms were once again adopted. However, a second limitation was the failure to implement any additional presentation times. It remains unknown as to how long individuals with chronic headache maintain their bias upon relevant pain information, and whether gaze is maintained consistently, or is directed away and then back towards this relevant information. Presentation times of 3000ms and 750ms would assist in providing respective answers. However, increasing the number of presentation times would also increase the experimental duration and participant burden (Kellough, Beevers, Ellis, & Wells, 2008), with a strong possibility of participant fatigue affecting results. Future research would therefore benefit from the implementation of concurrent eye-tracking technology, allowing for a continuous measure of attention across each trial.

Finally, it is important to note that while experimental images within the headache, pain, health-threat, and general-threat groups were closely matched with their neutral counterparts, differences existed between these stimuli groups. Headache images were more complex than pain images, as the former featured the models' face and hand/s, while the latter featured the models' face only. General-threat images were more colourful than all other image groups, as a number of images featured fire which is naturally bright. Although differences therefore existed between the four image groups, these were to a large extent unavoidable, as it was deemed more important to fully portray the respective forms of threat than to match

stimuli groups in every possible way. Despite this, image groups were matched where possible. Headache and pain images all featured models against plain backgrounds, although background colours did differ (headache images featured light coloured backgrounds [i.e. white or yellow/beige]; pain images featured light purple backgrounds). A greater consistency in background colour between image groups could therefore be aimed for in future research. For health-threat and general threat images, backgrounds were plain unless such content was necessary for the interpretation of the image (e.g. hospital beds and hotel beds shown in their respective environments). In sum, matching of stimuli between image groups is an important consideration in research such as this, although it will be inevitably impossible to match groups in all possible aspects.

In conclusion, the results from the current experiment add further support to the theoretical notion (e.g. Pincus & Morley, 2001) that individuals with chronic pain demonstrate attentional bias towards pain-related information. Addressing the specificity and time-course of bias, individuals with chronic headache, compared to healthy controls, demonstrated significantly greater bias towards headache-related images during maintained attention only. Supporting the content-specificity of bias, this group did not show significantly greater bias towards pain, health-threat, or general threat images. When compared to 0, the chronic headache group demonstrated significant bias towards headache images during both initial orienting and maintained attention, and bias towards pain expressions during initial orienting only. While no bias was observed towards health-threat images, it is possible that these images were not relevant enough to the specific concerns and fears held by the chronic headache sample. Alternatively, health-threat stimuli may simply not attract attention in individuals with chronic headache, with further research needed to explore these possibilities. Finally, supporting evolutionary accounts (e.g. Öhman et al., 2001), evidence for bias towards general threat was observed in all participants during both initial orienting and maintained attention. However, trend evidence suggested bias in initial orienting to be stronger in healthy controls participants. Overall, research utilising pictorial stimuli within the visual probe task has provided consistent evidence for attentional bias in chronic headache towards disorder-related information. An important area for future research involves the use of pictorial stimuli in alternative attention paradigms such as the emotional Stroop task. As

different cognitive paradigms may measure different aspects of attention (Brosschot et al., 1999; Johansson et al., 2004), an understanding of this is likely to be important in regards to both the refinement of theoretical models of attention and pain, and interventions aimed at reducing bias in individuals with chronic pain disorders.

## **Chapter 7**

### **Experiment 4: The Emotional Stroop Task and Attentional Bias in Chronic Headache**

#### **7.1 Summary**

This chapter presents the fourth experiment to be conducted on the PhD, which was an investigation into chronic pain attentional bias via the emotional Stroop task, with a consideration of the role of executive control. Sixty-seven participants took part in this study, including 32 with chronic headache, and 35 pain-free, healthy controls. Images of pain, angry, sad, fear, happy, and neutral facial expressions were presented in an emotional Stroop task in four different colours; red, blue, green and yellow. Contrary to the primary hypothesis, no evidence of attentional bias towards pain images was found in the chronic headache group. An investigation into executive control revealed no significant differences in performance between chronic headache and healthy control groups, although some evidence was found that bias towards happy expressions is related to executive control. Overall, these results are supportive of those found in Experiment 3, which together suggest that individuals with chronic headache do not bias attention towards general depictions of pain compared to healthy controls.

#### **7.2. Introduction**

Research investigating processes of attentional bias in chronic pain has typically made use of one of two paradigms; the emotional Stroop task or the visual-probe task. While initial research typically relied upon the former, the visual-probe task has gained preference in recent years among researchers in this field. Research adopting this paradigm with word stimuli has found mixed evidence, although the results of a meta-analysis (Study 1) has provided support that individuals with chronic pain demonstrate greater bias towards pain-related information than healthy

controls. Adopting pictorial stimuli in the visual-probe task, the results of Experiments 1 and 3 have provided evidence that, compared to healthy controls, individuals with chronic headache show attentional bias towards images depicting headache. Such research is therefore supportive of theories of attention and pain (e.g. Pincus and Morley, 2001) and theories of emotional processing (e.g. Wells and Matthews, 1994; 1996; Bower, 1981), all of which postulate cognitive bias towards relevant emotional information.

Developed by John Ridley Stroop (1935), the colour-word Stroop task is a classic experimental task in cognitive interference. Within this task, colour-names are presented to participants in either congruent (e.g. RED in red font) or incongruent (e.g. RED in blue font) coloured fonts. Colour naming has been demonstrated to significantly slow down during incongruent trials (Stroop, 1935), a factor likely attributed to reading automaticity (MacLeod & Dunbar, 1988). Emerging in the 1980's, the emotional Stroop task is an adapted version of the classic Stroop paradigm, requiring participants to colour-name emotional or threatening words. Performance times on emotional trials are often compared to trials with neutral, non-threatening stimuli (Thomas, Johnston & Gonsalvez, 2007), with an attentional bias deemed present if an individual takes significantly longer to colour name emotional words than their neutral counterparts.

#### *Former Research Utilising the Emotional Stroop Task in Chronic Pain*

The emotional Stroop task has produced little evidence that individuals with chronic pain show significantly greater bias towards pain-related information than healthy controls. Alternatively, evidence for within-group effects has been provided, showing that for pain patients, pain-related information interferes with colour-naming significantly more than non-pain information. However, not all studies have supported this finding, which is likely accounted for by methodological variations between studies. This body of research, which is summarised in Table 7.1, will now be discussed and evaluated.

Table 7.1. *Characteristics of studies using the emotional Stroop task to investigate bias in chronic pain in chronological order*

Study	Country	Stroop version	Stimuli words	Type of pain	Mean duration of pain	Sample size (pain/control)
Pearce & Morley (1989)	UK	Card	Sensory pain, affective pain, negative	Non-specified chronic pain	Mean not provided	16/16
Duckworth, Iezzi, Adams & Hale (1997)	USA	Computer	Pain, depression, neutral	Not provided	Mean not provided	19/10
Pincus, Fraser & Pearce (1998) – Exp 1	UK	Card	Sensory pain, affective pain, positive	Non-specified chronic pain	Mean not provided (range; 6 months to 10 years)	20/20
Pincus, Fraser & Pearce (1998) – Exp 2	UK	Computer	Sensory pain, affective pain, physical threat, positive, neutral	Non-specified chronic pain	Mean not provided (at least 6 months)	17/17
Snider, Asmundson and Wiese (2000)	Canada	Computer	Sensory pain, affective pain, physical threat, social threat, neutral	Back and/or neck pain	32.8 months	33/33
Crombez, Hermans and Adriaensen (2000)	Belgium	Computer	Sensory pain, affective pain, back disorder, other medical disorder, negative, neutral	Low back pain	10.44 years	25/0
Beck, Freeman, Shipherd, Hamblen and Lackner (2001)	USA	Computer	Pain, accident, positive, neutral	Heterogeneous (majority musculoskeletal)	Not specified (91% had pain for at least 3 months)	26/21 (also 28 pain with comorbid PTSD)
Andersson and Haldrup (2003)	Sweden	Computer	Personalised sensory pain, general threat, neutral	Heterogeneous	Mean not provided (range; 2 to 26 years)	20/20
Asmundson, Wright and Hadjistavropoulos (2005)	Canada	Computer	Sensory pain, affective pain, health catastrophe, neutral	Musculoskeletal	36.74 months	36/29

In the first published investigation, Pearce and Morley (1989) utilised sensory pain, affective pain, and negative emotional words within a Stroop task, along with neutral matches for each condition. Sixteen patients with chronic pain and 16 healthy control participants completed the task. Supporting the hypothesis, the results indicated that, compared to the healthy controls, patients with chronic pain demonstrated significantly greater Stroop interference with sensory and affective pain adjectives. No significant difference was found between the two groups in performance with the negative emotional adjectives. However, whilst it was also hypothesised that greater interference would be found with affective than sensory adjectives, this was not supported, as no significant difference was found between levels of Stroop interference from these two pain word categories.

Although the results from this initial study provide supportive evidence that individuals with chronic pain demonstrate biases in attention towards relevant pain stimuli, a limitation was the use of a non-computerised card version of the Stroop task. As response times depend up both participant and researcher (who uses a stopwatch), these are unlikely to be as accurate as computer tasks which automatically record times. Furthermore, if the researcher recording the time is not blind to the status of the participant (this was not specified), additional bias may be introduced into recording of response time. Subsequent research employing the computerised Stroop tasks has found no evidence for significant between-group differences, although evidence for within-group effects has been provided. Snider, Asmundson, and Wiese (2000) recruited 33 chronic pain and 33 healthy control participants, utilising sensory and affective pain words identical those used by Peace and Morley (1989), along with physical threat, social threat and neutral words. With depression as a covariate, no significant results were found for masked words presented for 14.3ms (i.e. outside of conscious awareness). For unmasked words, the chronic pain group showed significantly longer response times to both sensory and affective pain words compared to neutral words. Whilst no differences between the two pain word categories were found, only affective pain latencies were significantly slower than physical and social threat latencies (although a similar trend was reported for the sensory words). Overall, these results found significant within-group biases for the chronic pain group, although no significant differences to healthy controls were found (therefore differing to the results of Pearce and Morley). A limitation of this study was the recruitment of patient support staff for

the control group. As a result of their medical occupations, this group is likely to also be highly familiar with the pain words adopted in the study, possibly influencing patterns of bias. The ability to generalise results from this control group to the general population is therefore limited.

Beck et al. (2001) investigated specificity of bias in survivors of motor accidents. Twenty-six participants with pain, 28 with comorbid pain and post-traumatic stress disorder (PTSD), and 21 healthy controls were recruited. Pain, accident, positive, and neutral words were included in the Stroop task. The results provided support for the specificity of attentional bias, as the pain group displayed significantly slower response times to pain words, relative to accident, neutral and positive words (all  $p < .05$ ). In contrast, the pain group with comorbid PTSD showed slower response times to accident words, relative to positive and neutral words (both  $p < .05$ ), but not pain words. The control group displayed significantly slower responses to accident words than positive words ( $p < .05$ ). Considering the two pain groups, evidence for specific within-group biases was therefore found towards words representing ongoing concerns. Significant between group differences were also found ( $p < .05$ ), although these were not specific to stimuli type. Specifically, pain patients with comorbid PTSD displayed significantly slower response times than pain patients without PTSD. Likewise, both groups were significantly slower overall than healthy controls. However, it should be noted that across both pain groups, 8% did not meet criteria for chronic pain (i.e. pain for at least 3 months). All participants, however, had experienced pain for at least 1 month.

Further research has provided support for pain-related biases, although have been associated with methodological limitations. Crombez, Hermans, and Adriaensen (2000) investigated the presence of attentional bias in 25 patients experiencing chronic lower-back pain. Sensory and affective pain words were included in a computerised Stroop task, along with words associated with back disorders, other medical disorders, and finally general negative words. Neutral control words were paired with each threat word condition. The results indicated that, compared to neutral control words, patients were significantly slower to colour name sensory threat words ( $p < .05$ ). Aside from this, no further biases were found. Whilst these results suggest bias to be specific towards sensory dimensions of pain alone, the lack of a healthy control group limits the ability to conclude that such biases are exclusive to individuals suffering from chronic pain. Most recently, Andersson and Haldrup (2003) recruited 20 patients with chronic pain and 20

matched healthy controls. Participants were required to select 5 descriptive words best describing their pain from 19 items on the McGill Pain Questionnaire, which were subsequently used in a computerised Stroop task. Additionally, general threat words were also included, along with neutral matched words for each condition. The results showed chronic pain patients to respond significantly slower to pain words than neutral words ( $p = .04$ ), whilst healthy control participants showed a non-significant bias in the same direction ( $p = .12$ ). As no significant *group x word* interaction was found, it was argued that only indirect support was found to suggest that chronic pain patients differ to healthy controls in their attentional responses towards pain stimuli. A limitation of this investigation was that only pain patients idiosyncratically selected pain stimuli to be included. Thus, within this group, it is highly likely that bias towards pain words (relative to neutral words) resulted from priming effects.

A recent meta-analysis (Roelofs, Peters, Zeegers & Vlaeyen, 2002), utilising data from five former investigations (Pearce & Morley, 1989; Boissevain, 1994 [unpublished dissertation]; Pincus, Fraser & Pearce, 1998 [conducted 2 studies]; Snider et al., 2000), has provided supportive evidence for bias in chronic pain. All five studies included investigated attentional bias in chronic pain and healthy control participants, collecting response times with both sensory and affective pain stimuli. Response times from both forms of stimuli, along with their neutral counterparts, were used to compute interference scores for chronic pain and healthy control groups. Following this, scores from the control group were subtracted from the chronic pain group, resulting in a mean difference (MD) score for each study. The results of this meta-analysis showed significant MD estimates for both sensory ( $p < .002$ ) and affective ( $p < .001$ ) pain words, indicating participants with chronic pain to selectively attend to such stimuli compared to healthy controls. Furthermore, it was also suggested that, regardless of methodological differences between the five studies, MD estimations were relatively consistent. Despite these positive findings, however, a number of limitations should be highlighted. Firstly, as highlighted by the researchers, a small number of studies were included, which may represent an overestimation of attentional bias in individuals with chronic pain. Secondly, only one study reported significant between-group differences between chronic pain and healthy control groups (i.e. Pearce & Morley, 1989), and was rated as possessing the lowest methodological quality of all studies included.

Other investigations using the Stroop paradigm have reported null or ambiguous findings. Pincus et al. (1998) reported the findings of two investigations utilising the emotional Stroop task. The first task, designed as a replication of Pearce and Morley (1989), included 20 patients with chronic pain and 20 matched healthy controls. A card version of the Stroop task was used with sensory pain, affective pain and positive words, with neutral matches for each. The second task, including 17 chronic pain patients and 17 matched controls, provided a more in-depth investigation into the effects of anxiety and depression upon attentional bias. A computerised Stroop task was implemented, with sensory pain, affective pain, positive, physical threat, social threat and neutral (household items) words. The results from both investigations failed to provide evidence for significant attentional bias, either between or within groups. Significant correlations, however, were found between sensory and affective latencies with trait anxiety and depression respectively. It was therefore concluded that psychological constructs of anxiety and depression may be more strongly related to interference effects than pain intensity.

Investigating the role of somatic complaints, Duckworth, Iezzi, Adams and Hale (1997) recruited 19 chronic pain patients, dividing them into high ( $n= 10$ ) and low ( $n= 9$ ) somatic focus groups based upon the number of physical symptoms they reported. Additionally, 10 healthy controls were also recruited. Pain-related, depression-related and neutral words were included in a computerised Stroop task. The results found no evidence for specific bias towards pain words in either of the chronic pain groups. However, a main effect of group was found ( $p= .029$ ), showing chronic pain patients with high somatic focus to demonstrate significantly slower response times to all words types, compared to those with low somatic focus. No further differences between any of the groups were found. Considering the small sample sizes reported, however, caution needs to be taken with these results, as only large effects sizes would be detectable.

Most recently, Asmundson, Wright and Hadjistavropoulos (2005) investigated the consistency of findings across both Stroop and visual-probe paradigms, requiring patients with chronic musculoskeletal pain ( $n = 36$ ) and healthy controls ( $n = 29$ ) to complete both tasks. The same sensory pain, affective pain, health catastrophe and neutral word stimuli were included in the two tasks. No support for bias was found via the emotional Stroop task. However, evidence was found to suggest that this paradigm may measure different processes to the visual-probe task, with no significant

correlations found between the unmasked Stroop and visual-probe bias results. The similarities and differences between these two paradigms are discussed in detail in Chapter 8.

In summary, a number of studies have investigated attentional bias in chronic pain via the emotional Stroop task. Within this body of research only one study (i.e. Pearce and Morley, 1989) has provided evidence for significant between-group differences specific to pain-related words. Mixed support has been found for the presence of significant colour-naming interference on pain-related words in chronic pain patients (i.e. within-group effects), although most investigations suffered from methodological limitations. Additionally, a number of these former investigations are limited in that they recruited patients with non-specified forms of chronic pain (i.e. Pincus & Morley, 1989; Duckworth et al., 1997; Pincus et al., 1998), or failed to specify the mean duration of pain (i.e. Pincus & Morley, 1989; Duckworth et al., 1997; Pincus et al., 1998; Beck et al., 2001; Andersson & Haldrup, 2003). Replication of these studies and generalisation of their results is therefore problematic. Due to these issues, further research is needed with the emotional Stroop task. One avenue involves the implementation of pictorial stimuli, which have yet to be used in relation to this paradigm, along with recruitment of a well-specified pain sample. The current programme of research has provided evidence for significant between-group differences with pictorial stimuli via the visual-probe task (Experiment 1, Experiment 3). Should the emotional Stroop task measure similar attentional processes, it is possible that the implementation of pictorial stimuli may lead to more consistent evidence for between-group differences via this paradigm.

### *The Current Investigation*

Research has provided evidence that individuals with chronic headache demonstrate significant bias towards disorder-relevant (i.e. headache-related), pictorial stimuli (Experiment 1; Experiment 3). In contrast, evidence of bias towards more general pictorial pain stimuli (i.e. facial expressions of pain) is ambiguous. Recruiting individuals with newly developed musculoskeletal pain, Khatibi, Dehghani, Sharpe, Asmundson, and Pouretmad (2009) provided evidence that patients with high and low fear of pain significantly biased towards and away from painful expressions respectively. Experiment 3 found individuals with chronic headache to bias towards

such expressions when results were compared to 0, although only during initial orienting of attention. Both studies, however, failed to show that individuals with chronic pain bias towards general pain information significantly more than healthy controls. As only two former investigations have made use of such stimuli, further research is needed, with the current investigation therefore investigating bias towards pain expressions in an emotional Stroop task. Carry-over effects have been reported in this paradigm (e.g. Sharma & Money, 2010; Wilson, Sayette, Fiez, & Brough, 2007; Waters, Sayette, Franken & Schwartz, 2005), where “attentional effects elicited by exposure to salient stimuli “carry over” to influence the processing of the following trial” (Wilson et al., 2007. p 614). The current experiment therefore specifically included facial expressions of pain only, and not headache-related images. This decision prevented disorder-specific information influencing attentional patterns towards other facial expressions.

In addition to pain expressions, angry, sad, fear, and happy facial expressions were also included, along with neutral expressions devoid of any obvious emotion. These images allowed for further investigation into the specificity of chronic pain bias via the Stroop task. Additionally, greater comparison to the results of Experiment 2 was afforded, which also utilised angry, sad, and happy expressions in a visual-probe task. The inclusion of fearful facial expressions was deemed an important addition, as a fear of pain has been shown to be heightened in individuals with recurrent headaches, and is related to patient functioning and cognitive disruption (Hursey & Jacks, 1992). Norton and Asmundson (2004) have also provided evidence for a significant relationship between pain-related fear and escape/avoidance behaviours in a sample of 171 patients with recurrent headaches. Results of structural equation modelling revealed both anxiety sensitivity and pain severity to significantly load upon fear of pain. Considering such evidence for the role of fear of pain in chronic headache, the current investigation therefore examined whether individuals with chronic headache demonstrate bias towards fear expressions.

As the emotional Stroop task requires participants to perform quick colour discrimination, it is important to minimise the impact of deficiencies in colour vision upon results obtained from this paradigm. Colour vision deficiencies (also misleadingly known as ‘colour blindness’; Gordon, 1998) are a group of vision disorders characterised by the inability to distinguish two or more colours (Reber & Reber, 2001). Red-green deficiency is the most common form (Shin, Park, Hwang, Wee & Lee, 2007),

with approximately 8% of males and 0.5% of females in Europe and North America possessing such deficiencies (Krill, 1972). Considering this, it is surprising that only two former investigations (i.e. Beck et al., 2001; Asmundson, Wright et al., 2005) reported the presence of 'colour blindness' as an exclusion criterion, although even here it is unknown how this was established. The current investigation therefore excluded individuals with colour vision deficiency, using a combination of questioning, Ishihara colour plates, and testing with Stroop stimuli to achieve this.

Despite the increased interest in the presence of attentional biases in chronic pain, no research to date has investigated whether such biases are associated with more generalised deficiencies in executive control. If this were the case, evidence of attentional bias, as measured via the visual-probe or Stroop tasks, would perhaps indicate more general impairments, rather than those associated with selective attention alone. The investigation of this possibility is therefore warranted. Although definitions vary, executive control can be considered "a collection of interrelated abilities that enables people to modify their thoughts and actions" (Schmeichel, 2007. p 241), including emotional control, behaviour inhibition/impulse control, planning and organisation and working memory to name a few. Research has suggested impairments in individuals with chronic pain. In a recent review, Solberg Nes, Roach and Segerstrom (2009) highlighted the negative effects of chronic pain upon executive control, including difficulties in emotion regulation, social regulation and thought control. The ability to self-regulate aspects of behaviour is deemed crucial in chronic pain, with deficits linked to impairment in executive control. Based upon this, the current investigation therefore examined the relationship of attentional bias to executive control. According to Eslinger and Grattan (1993), two forms of frontal lobe function exist. Reactive flexibility refers to the readiness to freely shift cognition in response to altering demands of external situations. In contrast, spontaneous flexibility refers to the ready flow of ideas and answers in response to a question. Based upon this distinction, the current investigation adopted two measures of reactive and spontaneous flexibility, exploring the relationship between performance on these measures and bias via the emotional Stroop task.

Throughout the current programme of research, potential underlying correlates of attentional bias have been extensively explored. However, following the pattern of results highlighted in former published chronic pain research, little evidence has been provided to suggest any one variable underlies bias in chronic headache. Bias may

therefore be a relatively common phenomenon that is driven by the experience of pain itself, rather than any associated emotional issues (e.g. elevated anxiety, depression). An alternative possibility is that prior research has simply failed to consider the appropriate variable(s). While the current programme of research has measured functional headache disability, the impact of emotional disability specific to headache, and its relationship to bias, has yet to be explored. The current investigation therefore included a measure with specific subscales on emotional and functional disability in headache.

### *Aims and Hypotheses*

The primary aim of this experiment was to investigate attentional bias in individuals with chronic headache via the emotional Stroop task. A secondary aim was to investigate executive control via the Controlled Oral Word Association (COWA; Spreen & Strauss, 1998) test and the Comprehensive Trail-Making Test (CTMT; Reynolds, 2002). The following hypotheses were adopted:

1. Participants with chronic headache will demonstrate significant attentional bias towards pain-related images compared to healthy controls.
2. For participants with chronic headache, attentional bias towards expressions of pain will correlate with impaired executive control (as measured via COWA & CTMT).
3. Participants with chronic headache will demonstrate significantly poorer performance on measures of executive control (COWA & CTMT) than healthy controls.

### 7.3. Method

#### *Participants*

Participant recruitment strategies and inclusion and exclusion criteria are as specified in the General Methods of this thesis. In addition, any form of colour vision deficiency was adopted as a further exclusion criterion for both chronic headache and healthy control groups. An a priori power analysis indicated greater than 90% power to detect differences of magnitude 0.4 between groups for a sample size of 68 [(effect size = 0.40, Critical F (1, 66)= 3.99, Lambda= 10.88; GPower (Erdfelder et al., 1996). A total of 67 participants (mean age, 42.90, SD, 18.10; range 18 – 70 years) took part in this investigation, including 32 with chronic headache (mean age, 44.50, SD, 17.15; range 18 – 70 years) and 35 pain-free healthy controls (mean age, 41.43, SD, 19.05; range 18 – 70 years). The majority of participants were female (49; 73.1%). Participants with chronic headache reported living with headache for mean duration of 16.57 years (SD 15.15, range 21 months to 55 years), with the majority (22; 68.8%) reporting on average one headache per day. Fifteen (47%) were severely disabled as indexed by their MIDAS score, with functional disability significantly more pronounced than emotional disability as indexed via the HDI ( $t = 3.99, p < .001$ ). Twenty-three (71.9%) chronic headache participants reported at least one relative to also suffer from headache. Fifteen (47%) participants reported living with chronic tension-type headache, 16 (50%) with chronic migraine, and 1 (3%) with a diagnosis of concurrent chronic tension headache and chronic migraine. The majority of participants were taking regular medication to treat their headaches (30; 93.8%), with 23 (71.9%) reporting the use of prescription medication (including amitriptyline, sumatriptan, nortriptyline, domperidon, rizatriptan, zomatriptan, pizotifen, tramadol, diclofenac, and botulinum toxin), and 20 (62.5%) the use of over-the-counter medication (including aspirin, paracetamol, non-steroidal anti-inflammatory drugs, and combinations of paracetamol with other ingredients, including [most commonly] codeine phosphate, doxylamine succinate and caffeine). Across both groups, the majority of participants were married or in a relationship. Based upon the adopted criteria, 3 participants with headache disorders (6 – 12 headache days per month) were excluded from this investigation who did not meet diagnostic criteria for chronic headache, 3 due to psychiatric disorders (all chronic headache), 1 (chronic headache) due to the presence of another chronic pain condition (i.e. fibromyalgia), 5

due to being over 70 years of age (1 chronic headache, 4 healthy), and 3 due to colour vision deficiencies (2 chronic headache, 1 healthy).

### *Measures*

The questionnaire measures discussed in the General Methods section were included in the current investigation, in addition to the Pain Vigilance and Awareness Questionnaire (PVAQ; McCracken, 1997) and the Rumination-Reflection Questionnaire (RRQ; Trapnell & Campbell, 1999), which are discussed in Chapter 6. Furthermore, the following were newly adopted:

The Henry Ford Hospital Headache Disability Inventory (HDI; Jacobson, Ramadan, Aggarwal & Newman, 1994) is a 25-statement questionnaire measuring the impact of chronic headache upon daily living, which features two subscales for emotional and functional coping. Research has supported test-retest reliability over a period of 2 months ( $r = .76 - .83$ ; Jacobson et al., 1994; Jacobson, Ramadan, Norris & Newman, 1995), along with the internal consistency of the measure (.91; Kolotylo & Broome, 2000)

The COWA (also known as the FAS-test) (Spreen & Benton, 1977; Spreen & Strauss, 1998) is a commonly used executive control task. Participants are given a letter of the alphabet, and over a 60 second period are required to orally produce as many words as possible beginning with that letter. This process is repeated three times with separate letters. F, A, and S are the most commonly adopted letters (Spreen & Strauss, 1998), which were therefore used in the current investigation. The total number of correct words for each letter are summed into a single score. Proper nouns, repetitions, and word variations (e.g. Feed and Feeding) are removed as errors, which participants are informed of prior to the task. COWA is considered an executive control task because the organization of words by first letter is unfamiliar, and requires conscious, effortful, systematic organization. It is considered to reflect spontaneous flexibility (Spreen & Strauss, 1998; Wood & Lioffi, 2007), and reflects abstract mental operation related to problem solving, sequencing, resisting distractions, intrusions, and perseverations. Impairment on the task is associated with the

lateral, or the inferior prefrontal region, especially of the left hemisphere (Stuss et al., 1998). The COWA demonstrates good test-retest reliability (.74; Tombaugh, Kozak, & Rees, 1999).

The CTMT (Reynolds, 2002) features five paper-based visual-search tasks, each of which requires the participant to draw a trail between a series of ordered stimuli (i.e. sequenced numbers or letters) as quickly as possible. Although simple in appearance, performance relies heavily upon aspects of “attention, concentration, resistance to distraction, and cognitive flexibility (or set-shifting), in addition to the more obvious visual search and sequencing demands of the task” (Reynolds, 2002, p 2). Each trail, presented individually, is placed in front of the participant, who is then read standardised instructions detailing the requirements of the task, which encourage speed and accuracy. A stopwatch is used to time record time taken for each of the five trails. Raw response times are converted into T-scores, which in turn are summed and converted into a composite index score. CTMT is considered a measure of executive function because the individual is required to keep the number and letter sequences in working memory so as not to lose place. It is deemed a measure of reactive flexibility (Wood & Liossi, 2007), and recent fMRI studies (Zakzanis, Mraz & Graham, 2005) have confirmed the sensitivity of CTMT to frontal regions in the left hemisphere. Reynolds has provided evidence for the test-retest reliability (.92 for the composite index) and inter-rater reliability (.99 for the composite index) of the CTMT.

### *Experimental Stimuli*

Six image conditions were included within the emotional Stroop task, including pain, anger, sad, fear, happy, and neutral conditions. The same 6 models (3 male, 3 female) were included in all image conditions. Images were taken from the Montréal Pain and Affective Face Clips (MPAFC; Simon, Craig, Gosselin, Belin & Rainville, 2008), which is a database of video clips of models depicting differing facial expressions. Images were extrapolated from these one-second videos by pausing each clip when the emotional expression was deemed to be at its most intense. Following this

procedure, Adobe Photoshop 8.0 was used to create red, blue, yellow and green filters, each of which was placed over the original images as shown in Figure 7.1. Four versions of each original image were therefore included in all six emotional conditions, resulting in 24 unique image/colour combinations per condition. In addition, 8 buffer and practice trials were also developed in the same manner, featuring 2 different models (1 male, 1 female) not included in the main experimental trials. All images used within this task measured 148.17mm wide x 105.84 mm high (420 x 300 pixels respectively).



Figure 7.1. Example of pain images used in the Stroop task with red, blue, yellow and green overlaying filters (adapted from the MPAFC [Simon et al. 2008])

All images used in this experiment were rated for valence and arousal, similar to Experiments 1 to 3. Specifically, a computerized version of the Self Assessment Manikin (SAM; Lang, 1980) was implemented, randomly presenting images to participants for 3 seconds each. Following each image presentation, two 9-point SAM scales were presented; one for valence and one for arousal. Participants were required to indicate how happy and aroused they felt while viewing each image, using the computer mouse to provide their responses on the valence and arousal SAM scales respectively. Twelve independent participants (5 male, 7 female) completed this rating task (mean age 24.83; SD. 3.54). The results of this preliminary rating task for the current stimuli are presented in Table 7.2.

Table 7.2

*Mean (SD) valence and arousal of experimental and control stimuli used in the emotional-Stroop task*

	Pain	Angry	Sad	Fear	Happy	Neutral
Valence	3.83 (.41)	3.83 (.41)	3.83 (.41)	3.83 (.41)	6.50 (.55)	5.00 (.00)
Arousal	4.67 (.52)	3.83 (.41)	3.83 (.75)	4.67 (.82)	3.67 (.52)	2.83 (.41)

A Bonferroni correction for multiple comparisons was applied, with an accepted alpha of .002 adopted. Happy images were rated as significant more pleasant than pain, angry images (both  $t(5)= 8.00, p< .001$ ), sad and fear images (both  $t(5)= 12.65, p< .001$ ). Pain, angry, sad, and fear images were all rated as significantly less pleasant than neutral images (all  $t(5)= -7.00, p= .001$ ). Happy images were rated as significantly more pleasant ( $t(5)= 6.71, p= .001$ ) and arousing ( $t(5)= 5.97, p= .002$ ) than neutral images.

*Participant Screening for Colour Vision Deficiency*

As the emotional Stroop task requires participants to discriminate between four different coloured images, a number of steps were taken to ensure colour vision deficiencies did not affect performance. Firstly, participants were asked whether they

had been diagnosed with any form of colour vision deficiency, whether they noticed any particular problems discriminating colours, and whether there was a history of colour vision deficiency in their family.

Secondly, participants were presented with 9 computerised plates from the Ishihara colour test. While there are a number of different types of colour vision deficiency, the most common is the red-green deficiency (Shin et al., 2007), with the Ishihara test the most widely used for screening this deficiency (Birch, 1997). This test involves the display of a series of plates, each of which features a circle of coloured dots. Within each plate, a number is displayed that individuals with normal vision can detect, although is difficult to see for those with red-green colour vision deficiency. Based upon Hoffmann and Menozzi's (1998) recommendations for computer-based testing, each of the 9 plates were presented individually on a computer monitor for 3 seconds each. During this presentation, participants were required to verbally identify the number within each plate. Two or more incorrect answers (i.e. failure to respond or providing the wrong number) were recorded as evidence of potential colour vision deficiency. It was made known to participants that this was not an actual colour blindness test, but was used to indicate (in combination with the following) whether participants may have difficulties identifying colours on the computer monitor.

Thirdly, participants were shown four example stimuli not included in the experimental task, each of which featured a model with a neutral expression in red, blue, green, and yellow colours. Participants were asked to identify and distinguish the four colours. Finally, the researcher remained with the participant during the practice trials of the Stroop task to ensure that accurate identification of colours was being made. As noted above, 2 individuals with chronic headache and 1 healthy control were excluded due to colour vision deficiencies, specifically being unable to reliably discriminate the four colours used in the Stroop task.

### *Emotional Stroop Task*

The software package Presentation® (version 12.2, [www.neurobs.com](http://www.neurobs.com)) was used to develop the emotional Stroop task, which was run on an IBM compatible personal computer with a 15-inch colour monitor. A total of 144 experimental trials were presented, along with an initial 8 practice trials. In order to provide participants with a break, the task was split into two 72-trial blocks, with 4 buffer trials preceding each

block. The results of all practice and buffer trials were excluded from final analysis. In total, the entire task took approximately 10 minutes to complete.

Prior to the initial practice trials, participants were asked to read a set of on-screen instructions, which explained the nature of the task, along with the requirement to respond as quickly and accurately as possible. During the task, participants were presented with experimental trials in a randomised order, with each trial adhering to the same formula. Firstly, a fixation cross ( + ) was presented for 750ms in the centre of the screen. Immediately following this, a randomly selected image was presented in the centre of the screen, which remained until either a response had been provided or 4 seconds had elapsed. The inter-trial interval between trials was randomised between either 2500ms or 3500ms. Participants utilised a four-button response box in order to provide their responses, which featured red, blue, green and yellow stickers respectively placed above corresponding buttons. Participants were instructed to hold the box in their hands, resting their left thumb upon the red button, and the right thumb upon the yellow button. In this manner, the left thumb was used with red and blue buttons, whilst the right thumb was used with green and yellow buttons. Participants were seated approximately 60cm from the monitor, and therefore the visual angle of stimuli in this experiment was 10°.

### *Procedure*

The procedure is as specified in the General Methods, with the exception that participants completed the measures of executive control after the emotional Stroop task, and the questionnaires last. A break was provided between all three stages.

### *Data Reduction and Analytic Plan*

All data were analysed in PAWS Statistics 18 for Windows. Buffer and practice trials were excluded from final analysis, along with incorrect responses. Responses below 400ms and above 2000ms were removed to reduce the impact of outliers. Following this, mean response times were calculated for each participant, with any response time more than 3 standard deviations away from this mean also removed as individual outliers. As per previous research (e.g. Crombez et al., 2000) Stroop interference scores were calculated by subtracting mean response times for neutral control expressions from mean response times for each of the emotional expressions.

Positive scores indicate an attentional interference from the emotional expression, whereas negative scores indicate attentional avoidance of emotional expressions. Differences in demographic characteristics between groups were explored with  $\chi^2$  and t-tests for categorical and continuous variables respectively. A  $2 \times 5$  analysis of variance (ANOVA) on Stroop interference scores was conducted, with group (headache, control) as a between-subjects independent variable, and image type (pain, angry sad, fear, happy) as a within-subjects dependent variable. For this analysis, alpha level was set at .05, two-tailed. Pearson's correlation coefficients were calculated between the Stroop interference scores with the self-report measures, headache chronicity, and tests of executive control. The internal consistency of the self-report measures and their subscales were calculated with the use of Cronbach's alpha (Appendix E). Based upon the commonly used cut off of .70 (Christmann & Van Aelst, 2006), any measure/subscale falling below this value was deemed unreliable, and therefore not included in the correlational analysis.

## 7.4 Results

### *Group Characteristics*

To assess group equivalences, an independent samples t-test was conducted on *headache frequency*, while a chi-square analysis was conducted on the variable of *gender*. A one-sample Kolmogorov-Smirnov test revealed *age* to be non-normally distributed ( $Z= 1.38, p= .05$ ), and therefore a Mann Whitney U test was performed on this variable. As shown in Table 7.3, no significant differences between chronic headache and healthy groups were found for either *age* or *gender*, although as expected significantly more headache days per month were reported by the former.

### *Self-Report Measures*

Mean self-report data for both chronic headache and healthy groups are presented in Table 7.4. A series of independent t-tests were conducted on these measures. A Bonferroni correction for multiple comparisons was applied, with an accepted alpha of .004 adopted. Significantly higher levels of depression (HADS;  $p < .001$ ) were reported by chronic headache participants compared to healthy controls. In

addition, the chronic headache group also complete a series of additional questionnaires detailing their headache experiences, the results of which are presented in Table 7.5.

Table 7.3

*Group equivalence results (SD) for demographic variables and headache frequency*

Variable	Headache group ( <i>n</i> = 32)	Healthy group ( <i>n</i> = 35)	<i>t</i> / value/ <i>Z</i>	<i>df</i>	<i>p</i>
Headache frequency (Days per month)	24.41 (6.43)	1.80 (1.59)	19.38	34.46	.001
Gender (% female)	22 female (69%)	27 female (77%)	.60	1	.44
Age (in years)	44.50 (17.15)	41.43 (19.05)	-.48	-	.63

*Emotional Stroop interference scores*

The means for the various Stroop interference scores are presented in Table 7.6. The two groups did not differ significantly in the amount of RT data lost due to errors ( $M = 2.03\%$ ,  $SD = 2.07$ ), outliers ( $M = 1.95\%$ ,  $SD = 1.87$ ), or in overall mean RT ( $M = 934.80\text{ms}$ ,  $SD = 161.37$ ).

*Stroop interference analysis*

A 2 (*group*; chronic headache vs. healthy) x 5 (*image type*; pain vs. angry vs. sad vs. fear vs. happy) mixed designs ANOVA was conducted on participant *interference score* data. The results showed no significant main effect of *group*,  $F(1, 65) = 1.51$ ,  $p = .22$ , or *image type*,  $F(4, 260) = 1.18$ ,  $p = .32$ . No significant interaction was found for *group* x *image type*,  $F(4, 260) = 2.00$ ,  $p = .10$ .

In order to permit comparison with former Stroop research, image response times were compared to one another, with an accepted alpha of .003 adopted based upon a Bonferroni correction for multiple comparisons. No significant differences were found between any of the images for either the chronic headache or healthy control group.

Table 7.4

*Comparison of mean (SD) self-report scores for chronic headache and healthy control participants*

Measure	Chronic headache group ( <i>n</i> = 32)	Healthy group ( <i>n</i> = 35)	Mean difference	<i>t</i>	<i>df</i>	<i>p</i>
ASI	44.50 (17.15)	41.43 (19.05)	3.07	1.81	65	.075
MBSS M-B	5.59 (5.01)	5.74 (3.57)	-.15	-.14	65	.888
STAI state	30.59 (7.52)	31.43 (9.05)	-.84	-.41	65	.684
STAI trait	39.13 (10.95)	35.14 (9.43)	3.98	1.60	65	.115
TAS-20 total	48.88 (10.28)	43.91 (10.96)	4.96	1.91	65	.061
TAS-20 identify	17.75 (6.10)	14.17 (5.51)	3.58	2.53	65	.014
TAS-20 describe	11.72 (4.18)	12.26 (4.46)	-.54	-.51	65	.613
TAS-20 externally orientated thinking	19.41 (4.09)	17.49 (3.92)	1.92	1.96	65	.054
HADS anxiety	6.50 (3.12)	6.17 (2.57)	.33	.47	65	.639
HADS depression	4.84 (2.84)	2.46 (1.74)	2.39	4.10	50.45	.001
RRQ rumination	39.25 (11.23)	36.63 (10.00)	2.62	1.01	65	.316
RRQ reflection	35.31 (8.86)	38.34 (9.47)	-3.03	-1.35	64.96	.181

Note: ASI = Anxiety Sensitivity Index; MBSS = Miller Behavioral Style Scale; STAI = State Trait Anxiety Inventory; TAS = Toronto Alexithymia Scale (DIE = difficulty identifying emotions; DDE = difficulty describing emotions; EOT = externally-oriented thinking); HADS = Hospital Anxiety and Depression Scale; RRQ = Rumination-Reflection Questionnaire

Table 7.5

*Mean (SD) self-report scores for pain measures completed by chronic headache participants*

Measure	Chronic headache group ( <i>n</i> = 32)
CPAQ Total	65.34 (18.21)
CPAQ Willingness	28.00 (10.67)
CPAQ Activities	37.34 (11.53)
Dividing Attention	9.41 (7.36)
CSQ	
Reinterpretation CSQ	6.06 (7.15)
Catastrophising CSQ	11.22 (7.19)
Ignoring CSQ	12.56 (8.04)
Praying CSQ	8.41 (6.33)
Coping CSQ	19.53 (8.50)
IBA CSQ	13.94 (7.21)
Control CSQ	3.06 (1.44)
Decrease CSQ	2.72 (1.35)
HDI-Emotion	20.58 (10.00)
HDI-Functional	25.81 (9.78)
HDI Total	46.39 (18.38)
MPQ Sensory	15.22 (6.06)
MPQ Affective	5.22 (2.66)
MPQ Total (sensory + affective)	20.44 (7.95)
MPQ Present pain	38.41 (27.48)
MPQ Overall	3.25 (1.24)
PSEQ	36.22 (13.54)
PVAQ	43.63 (11.46)

Note: CPAQ = Chronic Pain Acceptance Questionnaire; CSQ = Pain Coping Strategies Questionnaire; HDI – Headache Disability Inventory; MPQ-SF = McGill Pain Questionnaire- short form; PSEQ = Pain Self Efficacy Questionnaire; PVAQ = Pain Vigilance and Awareness Questionnaire

Table 7.6

*Mean (SD) interference scores for chronic headache and healthy participants for each Stroop image condition*

Image	Chronic headache group ( <i>n</i> = 32)	Healthy group ( <i>n</i> = 35)
Pain score	-.34 (49.97)	-1.27 (56.96)
Angry score	-5.64 (49.86)	-4.40 (51.67)
Sad score	9.16 (47.75)	-17.77 (62.00)
Fear score	10.12 (52.37)	-2.98 (49.40)
Happy score	17.00 (51.87)	-5.12 (49.47)

*Comparisons to 0*

Interference scores were compared to 0, which corresponds to no impact of image type upon colour naming times (i.e. response times to both control images and experimental images are the same). No significant biases were shown by either chronic headache or healthy control groups to any of the emotional image categories employed. Similarly, when data from the two participants groups were combined, no significant biases were found. Individual 95% confidence intervals for all image groups across both participant groups are shown in Figure 7.2.

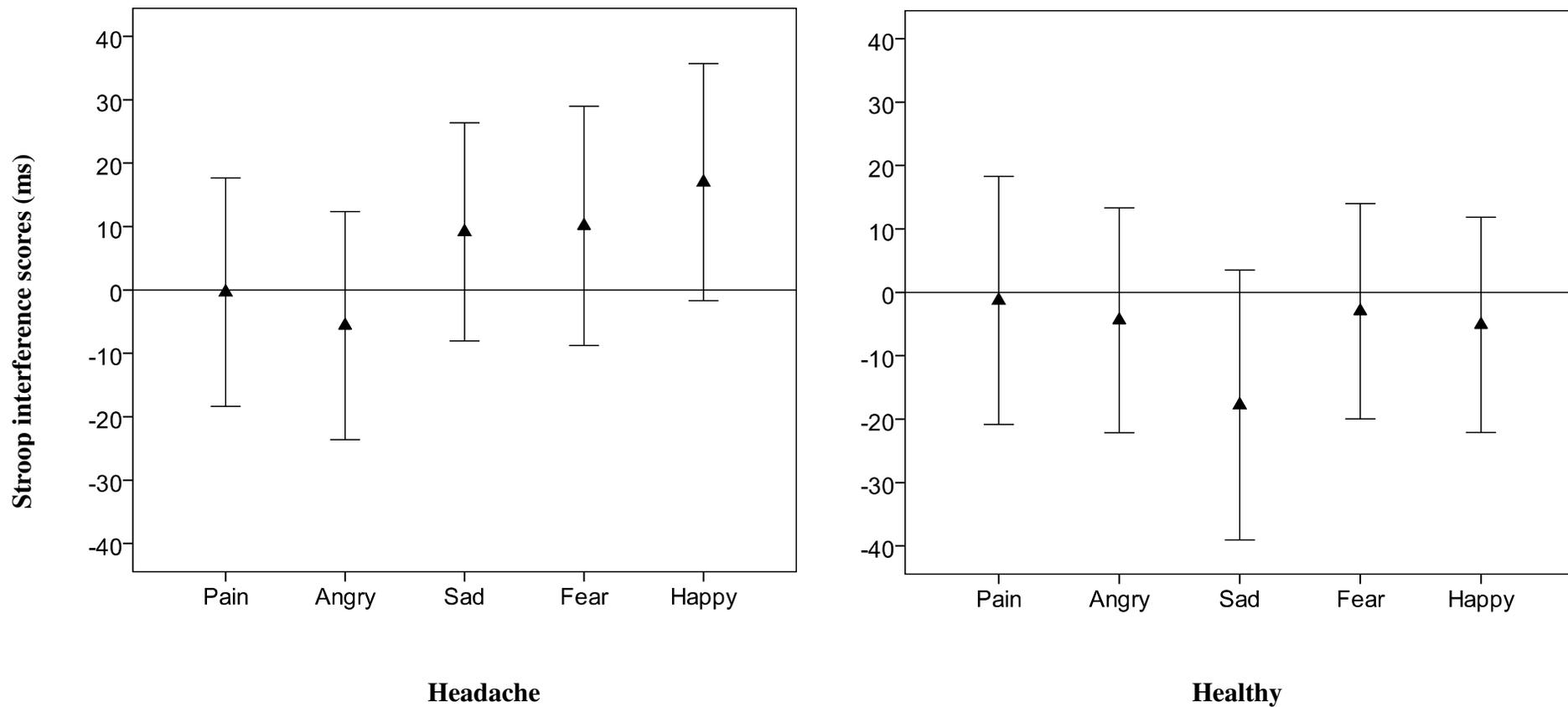


Figure 7.2. 95% confidence interval error bars for mean Stroop interference attentional bias scores across all image conditions for headache and healthy groups

### *Correlations between self-report measures and executive control with Stroop interference*

Correlations were computed between the various self-report measures and measures of executive control with Stroop interference scores, with the alpha level adjusted to  $p < .01$  due to the high number of calculations. The full correlation matrices can be found in Appendix D. Due to low levels of internal consistency, the following were not included in this analysis; the anxiety subscale of the HADS, the externally orientated thinking subscale of the TAS-20, the praying and hoping subscale of the CSQ, and the affective pain subscale of the MPQ-SF. For the chronic headache group, Stroop interference from happy faces was significantly correlated with state anxiety,  $r = .505, p = .003$ , catastrophising,  $r = .499, p = .004$ , emotional headache disability,  $r = .481, p = .006$ , and negatively correlated with pain vigilance and awareness,  $r = -.491, p = .004$ . Interference from sad faces was correlated with both emotional,  $r = .500, p = .004$ , and functional,  $r = .458, p = .009$ , headache disability, whilst interference from angry faces was correlated with functional headache disability,  $r = .497, p = .004$ . Performance on the COWA was negatively correlated with the happy interference score,  $r = .514, p = .003$ . For healthy control participants, no significant correlations were found for either self-report measures or measures of executive control. Data from both groups were also combined into a single sample ( $n = 67$ ). Results from this single sample revealed significant positive correlations between trait anxiety and interference from pain,  $r = .322, p = .008$ , sad,  $r = .356, p = .003$ , and happy,  $r = .332, p = .006$ , faces. A significant negative correlation was also found between COWA performance and the happy interference score,  $r = -.400, p = .001$ .

### *Measures of Executive Control*

Independent t-tests were used to compare the chronic headache and healthy control groups on measures of executive control, the results of which are presented in Table 7.7. For the COWA, no significant differences were observed between the two groups in either the number of correct words generated  $t(65) = .27, p = .79$ , or the number of incorrect responses made,  $t(65) = .84, p = .40$ . For both groups, the mean number of responses produced was similar to the normative values provided by Tombaugh, Kozak and Rees (1996, cited in Spreen & Strauss, 1998), who reported a mean of 46.9 ( $SD = 11.8$ ) responses across all education levels ( $N = 894$ ).

For the CTMT, mean response times were converted into t-scores for each of the five trails. Additionally, an overall CTMT composite index was calculated. Six participants were unable to complete trail 5, and therefore their composite indices were calculated from the results of four trails only, following the procedure specified in the CTMT examiner's manual for such circumstances (Reynolds, 2002). The results revealed no significant difference between the chronic headache and healthy control group in overall performance, as measured by the CTMT composite index,  $t(65) = -.41$ ,  $p = .69$ . Additionally, no significant differences were found for performance on any of the five trails, as measured via the calculated t-scores (trail 1:  $t(65) = -.99$ ,  $p = .33$ ; trail 2,  $t(65) = -.61$ ,  $p = .54$ ; trail 3,  $t(65) = -1.25$ ,  $p = .22$ ; trail 4,  $t(65) = .72$ ,  $p = .48$ ; trail 5,  $t(49) = .32$ ,  $p = .75$ ). Based upon performance levels suggested by Reynolds, both chronic headache and healthy control groups demonstrated average performance on the CTMT.

Table 7.7.

*Mean COWA and CTMT scores (SD) for chronic headache and healthy participants*

Measure	Chronic headache group ( $n = 32$ )	Healthy group ( $n = 35$ )
COWA score	43.25 (12.97)	42.46 (11.22)
CTMT composite index	50.59 (9.07)	51.46 (8.39)
Trail 1 score	48.75 (9.18)	50.83 (8.01)
Trail 2 score	52.59 (10.54)	54.14 (10.17)
Trail 3 score	49.59 (10.82)	52.66 (9.29)
Trail 4 score	51.34 (10.59)	49.51 (10.27)
Trail 5 score	52.22 (10.60)	50.46 (12.01)

## 7.5. Discussion

The aim of the current experiment was to investigate attentional bias in chronic headache utilising an emotional Stroop task with pain, angry, sad, fear, and happy facial expressions. The results did not support the primary hypothesis, as significant bias toward pain images was not found in individuals with chronic headache. A further aim was to explore the role of executive control in attentional bias. Contrary to the second hypothesis, bias towards pain expressions was not correlated with impaired executive control in the chronic headache group. Support for the third hypothesis was also not provided, as individuals with chronic headache did not differ to healthy controls in executive control performance. Overall, the results of the current investigation replicate the majority of former Stroop studies, finding no evidence of significant between-group differences in Stroop performance. These results also support those reported in Experiment 3, together suggesting individuals with chronic headache do not show attentional bias towards facial expressions of pain relative to healthy controls.

Research using the emotional Stroop task has found little evidence to suggest individuals with chronic pain demonstrate significantly different patterns of attentional bias compared to healthy controls. Indeed, of the nine experiments published to date, only Pearce and Morley (1989) found evidence of significant differences between groups. While a meta-analysis of 5 investigations supports this (Roelofs et al., 2002), this analysis included Pearce and Morley's study, which presented the greatest evidence of bias, but also the weakest methodological rigour. Due to the small number of included studies, the significant result found in this meta-analysis is likely to have been driven by this single study. The current experiment is therefore supportive of the majority of former investigations, together suggesting the Stroop task is not an efficient paradigm to explore between-group differences in this particular field. Potential explanations for this are unclear, as the Stroop task has been shown to reliably detect between-group differences in anxiety, with comparable performance to the visual-probe task (Bar-Haim, Lamy, Lee, Bakermans-Kranenburg & IJzendoorn, 2007).

In contrast to the above, former research has provided some evidence that, for individuals with chronic pain, pain-related words interfere with colour naming to a significantly greater degree than neutral words (i.e. Snider et al., 2000; Beck et al., 2001; Crombez et al., 2000; Andersson & Haldrup, 2003). Furthermore, Snider et al. also

reported greater interference compared to physical and social threat words, while Beck et al. found greater interference compared to accident and positive words. Based upon past research, the Stroop task therefore appears to more reliably detect within-group differences in chronic pain samples. However, the results from the current investigation are not supportive of this, as pain expressions did not significantly interfere with colour naming in the chronic headache group compared to any other facial category (i.e. neutral, angry, sad, fear, happy expressions). Furthermore, a comparison of interference scores to 0 also failed to highlight any significant evidence of bias. As the current investigation is the first to utilise pictorial stimuli, one possibility is that such stimuli are less likely to interfere with colour-naming than words. Conducting a meta-analysis into anxiety biases, Bar-Haim et al (2007) found evidence for significant bias for threatening words used in the Stroop task, but not for threatening pictures. In contrast, a recent investigation found evidence for bias with pictorial stimuli, but not word stimuli (Reinholdt-Dunne, Mogg & Bradley, 2009). Evidence of the efficacy of pictorial stimuli in the Stroop task is therefore mixed, although it is important to note that as different patterns of bias exist between individuals with anxiety and chronic pain, generalising results between these two conditions may be unwise. Supporting this, bias is more prominent at shorter presentation times in anxiety (Bar-Haim et al., 2007), but longer presentation times in chronic pain (Liossi et al., 2009; Experiment 1; Experiment 3).

According to theories of emotional processing (e.g. Wells & Matthews, 1994; 1996; Bower, 1981), cognitive biases are predicted towards information congruent with an individual's concerns. A more likely explanation for the lack of significant results in the current investigation is that the facial expressions of pain were not relevant enough to the concerns of the chronic headache sample recruited. An argument may be made that pain expressions alone are relatively ambiguous, providing no information on pain characteristics such as location, intensity, or duration. The results of Experiments 1 and 3 provide evidence that individuals with chronic headache bias towards headache-related images relative to healthy controls. These differ to the pain expressions utilised in the current study in that a degree of context is provided, whereby the location of pain is shown in the head region. Individuals with chronic headache may therefore be relatively unconcerned with generic pain information, accounting for the lack of between-group differences in the current investigation and Experiment 3 (comparison of current results to Khatibi et al. [2009] are problematic, as discussed in Chapter 6). Overall, this notion

has implications for theoretical models of attention and pain (e.g. Pincus & Morley, 2001), which predict individuals with pain should demonstrate bias towards pain-related information and cues. The results from the current investigation are suggestive that the characteristics of such stimuli play an importance role in determining whether bias will be shown. These theoretical implications shall be discussed in depth in the following chapter (Chapter 8), which indicates the need for a refined theoretical account of attention and pain.

In order to investigate bias specificity, angry, sad, fear, and happy facial expressions were also included in the Stroop task. Supporting the results of Experiment 2, chronic headache and healthy control groups did not differ in their patterns of attention to angry, sad, or happy expressions. Similarly, no evidence was found to suggest individuals with chronic headache bias towards facial expressions of fear, although it is important for future research explore this area in more depth. Specifically, as individuals with comorbid emotional disorders were excluded from participation, it is possible that these findings are not representative of the chronic headache population as a whole. Caution therefore needs to be made in generalising the current results. Future research would benefit from recruiting chronic headache patients with and without comorbid emotional disorders, investigating potential similarities and differences in attentional bias. Regardless of this, the current results with angry, sad, fearful and happy facial expressions are supportive of theories of emotional processing, including Wells and Matthews' (1994; 1996) Self-Regulatory Executive Function Model (S-REF) and Bower's (1981) network model, which suggest cognitive biases are associated with information relevant to an individual's concerns only.

To investigate aspects of executive control in chronic headache, the current investigation utilised two separate tasks, measuring reflective (CTMT), and spontaneous (COWA) flexibility. To date, no published research has investigated whether general deficiencies in executive control underlie bias in chronic pain. No significant correlations were found between Stroop interference from pain expressions and measures of executive control. The notion that pain-related biases in individuals with chronic headache are due to deficiencies in executive control is therefore unsupported, providing no evidence for the adopted hypothesis. However, it is important for future research to investigate this area further, as executive control refers to a number of interrelated cognitive abilities (Schmeichel, 2007). One particular avenue for

investigation is the role of attentional control, which refers to the success to which individuals are able to focus or shift their attention when desired (Moriya & Tanno, 2008). No research to date has explored whether impairments in attentional control underlie bias in chronic pain, although may be investigated via paradigms such as the anti-saccade task (Hallett, 1978).

In contrast to the above, a significant negative correlation was found between interference scores for happy expressions and executive control in the chronic headache group, and also when participants from both groups were combined. Individuals with high executive control may therefore be more successful at overriding potential interference effects from positive emotional stimuli. On the other hand, attention to threatening or negative expressions appears to be unrelated to aspects of executive control. These findings support the notion that individuals are evolutionarily primed to automatically detect threat as a survival mechanism (Öhman, Flykt & Esteves, 2001). As happy facial expressions are unrelated to threat, attention towards these expressions may be under more voluntary control, and thus influenced by more general executive control. However, this conclusion should be made with caution, as this significant relationship was only found with the COWA and not the CTMT.

As negative effects in executive control have been noted in chronic pain (Solberg Nes et al., 2009), it was predicted that the chronic headache sample would show deficits compared to healthy controls. No evidence to support this prediction was found, however, with chronic headache and healthy control groups demonstrating approximately equal performance on both COWA and CTMT tasks. Further to this, neither group was found to deviate in performance from normative values provided by other researchers. However, it is possible that support for this hypothesis was not obtained due to exclusion of participants with emotional disorders. Reviewing the relevant literature, Hart, Wade and Martelli (2003) have noted that for patients with chronic pain, emotional distress plays a significant role in cognitive impairment. Indeed, partialling out the effects of distress, or screening patients for emotional disorders, typically results in little to no evidence of impairment.

Further to the above, analysis revealed a number of additional correlations between self-report measures and Stroop interference. For the chronic headache group, bias towards sad expressions was correlated with both emotional and functional headache disability. Furthermore, emotional disability was correlated with bias for angry

and happy facial expressions. Individuals who perceive themselves as disabled by their chronic headache therefore show increased bias for emotional information in general. It is interesting, however, that no significant correlations were found between perceived disability and bias for pain and fear expressions, with further research needed to explore potential reasons for this pattern of findings. Perceptions of disability have been associated with negative outcomes in patients with chronic pain (Gallon, 1989), although it is notable that little research has specifically addressed this issue.

For the chronic headache group, bias for happy expressions was also correlated with both state anxiety and catastrophising. These results support the significant correlation between state anxiety and bias for happy expressions found in Experiment 2. Attention towards such expressions may represent a form of mood or emotion regulation, whereby the negative effects of pain are countered to some degree by a focusing upon positive information. Emotion-focused coping has shown benefits in a range of disorders including chronic pain (Austenfeld & Stanton, 2004). It is important to note, however, that bias to happy expressions was negatively correlated with a subjective measure of pain vigilance and awareness. Individuals who are highly attentive to physical pain may therefore be less inclined or able to bias towards happy expressions due to increased focus upon their present levels of pain. Further research is needed into the efficacy of emotion regulation in chronic headache, as it remains unknown whether focusing upon positive information has beneficial effects for people with this specific type of chronic pain.

With participants from both groups combined, trait anxiety was positively correlated with bias towards pain, sad, and happy facial expressions. As anxiety is associated with a hypervigilance for threat (Beck et al., 1985), it is unsurprising that individuals with increased anxiety would bias their attention towards pain and sad expressions (the correlation with happy expressions appears to be primarily driven by the chronic headache group, which is discussed above). However, the lack of significant correlation between anxiety and bias towards anger and fear expressions is notable, especially as biases towards such expressions have been associated with heightened anxiety (e.g. Mogg, Garner, & Bradley, 2007). However, as comorbid emotional disorders (including anxiety) were exclusion criteria in the current investigation, patterns of bias may differ from those shown in other investigations recruiting individuals with anxiety at clinical levels.

A number of limitations should be highlighted with the current investigation. Firstly, as only pain expressions were used, no information was gathered in regards to bias towards disorder-specific images (i.e. headache images). This decision was made to eliminate the possibility of carry-over effects from headache images influencing the processing of pain images. However, questions remain surrounding the efficacy of the emotional Stroop task to detect between-group biases in this field of research. While it has been noted that the Stroop task may not be a reliable measure of such differences, it is possible that the use of disorder-relevant stimuli would lead to more consistent evidence of between-group differences. A similar pattern of findings is notable with the visual-probe task, which only produced consistent evidence for between-group differences with highly relevant headache stimuli (i.e. Lioffi et al., 2009; Experiment 1; Experiment 3). The next logical step for future research to take would be to therefore adopt disorder-relevant pictorial stimuli in the Stroop task.

Similar to the majority of former non-pain research (e.g. Mathewson et al., 2010; Reinholdt-Dunne, Mogg & Bradley, 2009), each image in the Stroop task was tinted in red, blue, green, and yellow shades. As the entire image was coloured, this method encouraged participants to view the facial expression of each model. One potential limitation of this practice, however, is that facial expressions may have been obscured to some degree by the colour tint. However, preliminary testing with these images revealed no problems in viewing the actual expressions. Furthermore, each participant was shown example stimuli as part of the colour vision deficiency test, with none reporting difficulty in seeing the facial characteristics of the models. A further limitation, however, is that as the background of each image was also coloured, participants may have focused upon this instead of the model's face. Although this remains a possibility, faces naturally capture attention (Vuilleumier, 2000; Schmidt & Cohn, 2001), and it is therefore likely that participants viewed the expressions to some degree. However, interference in colour-naming may have encouraged some to shift gaze to the background to determine the colour, although this process would itself increase response latencies and likely lead to evidence of significant bias. Despite this, the recommendation is made for future research to use facial expressions alone, omitting all background content.

The current experiment is the only known study to investigate bias in chronic pain via a Stroop task with pictorial stimuli. As such, a number of possibilities for future

research remain. Firstly, and as discussed above, an investigation of pain-bias specificity is needed via this paradigm. To date, only one investigation (i.e. Experiment 3) has implemented both disorder-specific and general pain pictorial stimuli in this field of research, which was conducted with the visual-probe task. Future research investigating bias in chronic headache via the Stroop task would benefit from an inclusion of both headache and pain images, although alternative methods to overcome potential carryover effects should be implemented. Secondly, it would be advantageous for research to utilise pictorial and linguistic versions of the Stroop task with the same chronic pain and healthy control samples. This would allow investigation as to whether the type of stimuli influences bias in this paradigm. Finally, there is a need for further research to address whether the emotional Stroop and visual-probe tasks measure the same aspects of attention, as a number of researchers have suggested that different stages of attention may be measured (Brosschot et al., 1999; Johansson et al., 2004). Considering chronic pain, only Asmundson, Wright et al. (2005) have utilised both paradigms with the same chronic pain sample, reporting evidence that different processes may in fact be measured. Further research is therefore needed, which is discussed in depth in Chapter 8.

In conclusion, the results from the present investigation provide no evidence to suggest that individuals with chronic headache demonstrate attentional bias towards facial expressions of pain. These findings are therefore supportive of those reported in Experiment 3, together suggesting that expressions of pain may not be relevant enough to these individuals to elicit significant bias relative to healthy controls. Investigating processes of executive control, the current investigation found some evidence that deficits in this cognitive ability are related to bias to happy expressions. However, no evidence was found that these underlie biases towards pain expressions. Furthermore, performance on measures of executive control did not differ between chronic headache and healthy control groups. Overall, the results from the current programme of research support the view that attentional bias in chronic headache is predominately displayed towards disorder relevant information. This finding, along with theoretical and clinical implications, and suggestions for future research, are discussed in in-depth in the following chapter.

## **Chapter 8: General Discussion and Conclusions**

### **8.1 Summary**

This chapter presents a detailed discussion of the results drawn from the current programme of research investigating attentional bias in chronic headache. An overview of this research is firstly presented, summarising the rationale, hypotheses, and results of each investigation. The main findings are then discussed, including the evidence of attentional bias found, emotional functioning in chronic headache, and underlying correlates of bias. The theoretical implications of these results are then presented, including a preliminary account of bias in chronic pain detailing the importance of both time-course and specificity. This is followed by a discussion of the potential clinical implications of these findings. Finally, limitations of the current programme of research are discussed, along with possibilities for future research in the field of attentional bias in chronic pain.

### **8.2. Overview of the Current Programme of Research**

Theoretical accounts of emotional processing (e.g. Wells and Matthews, 1994; 1996; Bower, 1981), and attention and pain (e.g. Pincus & Morley, 2001), support the notion that individuals with chronic pain should display cognitive biases towards information relevant to their pain disorder. The programme of research presented in this thesis has investigated this notion, addressing whether individuals with chronic pain demonstrate attentional bias towards pain-related information. This included a systematic review and meta-analysis of former research exploring bias via the visual-probe task, three empirical investigations utilising the visual-probe task, and one investigation with the emotional Stroop task. The main aim of this research was to determine whether attentional bias towards pain-related information exists in individuals with chronic pain, with a specific focus upon chronic headache. Further to this, the current research also sought to clarify both the time-course and specificity of attentional bias, both of which have not been adequately explored in previous research. Finally,

evidence of underlying correlates of bias in chronic pain has remained elusive. The current research explored potential correlates, including a number not formerly addressed, such as pain acceptance, pain coping strategies and perceptions of headache-related disability.

More specifically, Study 1 (Chapter 3) presented a systematic review and meta-analysis of former research to utilise the visual-probe task, comparing bias towards pain-related information in individuals with chronic pain and healthy controls, at presentation times associated with initial orienting of attention (i.e. 300 – 500ms). Individuals with chronic pain were shown to demonstrate significantly greater bias towards pain-related information compared to healthy controls. However, there was significant study heterogeneity, and removal of the most methodologically different study (i.e. Khatibi, Dehghani, Sharpe, Asmundson & Pouretamad, 2009) resulted in only trend evidence for bias in chronic pain patients. The results of this study were of practical importance, and support the continuing use of stimuli presentation times associated with initial orienting in the visual-probe task, along with well-defined pain samples as opposed to samples of patients with mixed, heterogeneous chronic pain.

Experiment 1 (Chapter 4) provided an investigation into the time-course of attentional bias, recruiting individuals with chronic headache and healthy controls. Stimuli presentation times of 500 and 1250ms were adopted to investigate bias in initial orienting and maintained attention respectively. In order to make stimuli as relevant as possible to the experimental group, headache-related images were included in the visual-probe task. Supporting the adopted hypothesis, individuals with chronic headache demonstrated significantly greater bias towards headache images compared to healthy controls. However, no evidence was found for significance of presentation time, with bias observed across both stages of initial orienting and maintained attention. It was therefore concluded that biases are common in those with chronic headache, being shown towards disorder-relevant information.

Experiment 2 (Chapter 5) aimed to clarify and expand upon the results found in Experiment 1, addressing the specificity of bias in chronic headache. A noted limitation of the headache-related images used in Experiment 1 was a level of ambiguity in the facial expressions depicted. Although these images had been validated as predominately reflecting pain, independent raters also noted lower levels of anger and sadness within this stimuli set. Experiment 2 therefore utilised a similar visual-probe task to that of

Experiment 1, albeit with angry, sad and happy facial expressions. No significant differences in attentional bias were predicted between the chronic headache and healthy control groups. The findings supported this hypothesis which, in combination with those of Experiment 1, supports the notion that bias in chronic headache is specific towards disorder-related information only.

Experiment 3 (Chapter 6) further explored the specificity and time-course of bias in chronic headache, addressing a number of unanswered questions stemming from former research, including Experiments 1 and 2. Firstly, it was examined whether biases in chronic headache are shown towards disorder-relevant stimuli only, or are also shown towards more general representations of pain. It was hypothesised that significant differences between the two participant groups would only be found with headache-related stimuli. Secondly, as the experience of chronic pain may be associated with fears concerning deterioration of health, bias towards images of objects representing illness and poor health was investigated. Thus, it was hypothesised that, within the chronic headache group, fear of pain would significantly correlate with bias towards health-threat images. Thirdly, bias towards general, non-pain related threat was explored in order to build upon the knowledge generated in Experiment 2, although no significant difference in bias between the two participant groups was expected with this stimuli set. Finally, underlying correlates of bias were further explored, with the prediction that rumination and pain vigilance would significantly correlate with bias towards headache and pain images respectively in the chronic headache group. In order to address these questions, headache-related, pain, health-threat and general-threat images were included in a visual-probe task, displayed at presentation times associated with initial orienting and maintained attention. Supporting the first hypothesis, chronic headache participants showed significant bias towards headache-related images compared to healthy controls. However, this difference was only found for stimuli presented at the longer presentation time (i.e. 1250ms) associated with maintained attention. In contrast to the second hypothesis, no significant correlation was found between fear of pain and health-threat bias in the chronic headache group. Similarly, the third hypothesis was unsupported, with no significant correlations found between rumination and pain vigilance with headache-related and pain images bias respectively. Overall, these results support the notion than individuals with chronic headache bias towards disorder specific stimuli, at

presentation times associated with maintained attention, possibly as a result of rumination.

Experiment 4 (Chapter 7) adopted an emotional Stroop task to further investigate bias in chronic headache participants and healthy controls. While all former chronic pain investigations with this paradigm have made use of linguistic stimuli, Experiment 4 utilised pictorial stimuli depicting facial expressions of pain, anger, sadness and happiness. Chronic headache participants were hypothesised to show significantly greater Stroop interference on pain images compared to healthy controls. Contrary to this hypothesis, no significant differences in Stroop performance were found between the two participant groups in regards to any of the images. This study also investigated the role of executive control, although found no evidence to suggest that pain-related biases in individuals with chronic headache are due to deficiencies in executive control. However, a significant negative correlation was found between interference scores for happy expressions and executive control, suggesting that individuals with high control may be more successful at overriding potential interference effects from positive emotional stimuli. Taken in combination with the results of Experiment 3, individuals with chronic headache appear less likely to bias towards general representations of pain than towards disorder-specific information.

### **8.3. The Pattern of Attentional Bias in Chronic Pain**

#### *Attentional Bias in Chronic Pain*

The research presented in this doctoral thesis has met the aims specified in the thesis introduction, providing evidence for attentional bias in individuals with chronic pain and addressing the time-course and specificity of such bias. Prior to this, evidence for attentional bias in chronic pain was mixed. Research utilising the visual-probe task in particular had found little evidence to support the presence of such bias. Furthermore, with the exception of Lioffi et al (2009), no former investigation with adult samples had explored the importance of bias time-course in chronic pain. Bias towards stimuli presented for 500ms is considered to reflect initial orienting of visual attention (Bradley, Mogg & Miller, 2000; Mogg, Miller, & Bradley, 2000; Gamble & Rapee, 2009). This process itself reflects hypervigilance, where the individual scans their environment for

potential sources of perceived danger (Beck et al., 1985), and is considered to be largely automatic (McNally, 1995; Van Damme & Eccleston, 2005). Stimuli presentation of 1250ms allows for multiple shifts in visual attention (Mogg & Bradley, 1998). As a result, bias at this stage may reflect processes of maintained attention, where despite having time to shift away from the emotional stimulus, attention instead remains focused upon it. It is notable that longer stimuli presentation times offer the opportunity to excessively elaborate or ruminate upon emotional information, whereas shorter presentation times do not (Donaldson, Lam & Matthews, 2007).

Taken in combination, the results of the current programme of research suggest that, relative to healthy controls, individuals with chronic pain do display attentional bias towards pain-related information, across stages associated with initial orienting of attention (Study 1, Experiment 1) and maintained attention (Experiment 1, Experiment 3). However, this bias is more prominent during the latter stage, a finding supported by the results of Lioffi et al (2009). Thus, when relevant pain-related information is encountered, individuals with chronic pain may be particularly prone dwelling or ruminating upon such information. Donaldson et al. (2007) have noted that should biases be dependant upon elaborative processes, evidence for such bias is likely to be more fragile at shorter presentation times (e.g. 500ms) which do not offer the opportunity for extensive elaboration. This explanation supports the pattern of bias observed in individuals with chronic headache, which across both experiments (i.e. Experiments 1 and 3) and Lioffi et al. (2009) has been more prominent at 1250ms than 500ms.

Further to bias time-course, the current research has provided important information on bias specificity, in that individuals with chronic headache have been shown to bias towards disorder-related information only when compared to healthy controls. In contrast, no significant biases relative to controls were found towards general depictions of pain (i.e. facial expressions of pain), information related to health or illness, general-threat information, depictions of interpersonal threat (i.e. angry, sad, or fearful facial expressions), or happy facial expressions. The results from Experiments 1 to 4 therefore support theories of emotional processing (Wells and Matthews, 1994; 1996; Bower, 1981), which predict information-processing biases towards information congruent with an individual's concerns.

In addition to between-group comparisons, attentional bias was also investigated via within-group comparisons to 0, which theoretically equate to no attentional bias

either towards or away from emotional stimuli. This form of analysis has been adopted in some former attentional bias investigations (e.g. Khatibi et al., 2009), although not all researchers have opted to use this (e.g. Asmundson, Carleton et al., 2005). Comparisons to 0 were included in the current programme of research (i.e. Experiments 1 to 4) however, as they provide a method of clarifying any between-subjects effects that may be found (Joormann & Gotlib, 2007) (see Chapter 6 for a more in-depth discussion). Of relevance to the current debate, Experiment 3 found participants with chronic headache to show bias significantly greater than 0 towards headache images presented for both 500 and 1250ms. These results therefore compliment the between-group results discussed above, showing that individuals with chronic headache demonstrate significant bias *towards* disorder-relevant information, at stages of initial orienting and maintained attention. However, once again bias was more prominent during the latter. Furthermore, individuals with chronic headache appear to only ruminate on disorder-relevant information, as comparisons to 0 only found evidence of significant bias towards generalized facial expressions of pain when presented for 500ms. This effect was only found in Experiment 3, however, with Experiment 4 finding no such evidence.

To summarise, attentional bias in chronic headache is more prominent during stages of maintained attention, which is consistently found towards disorder-relevant information. These findings provide a likely explanation for the pattern of findings reported in previous visual-probe investigations, the majority of which found no significant differences between chronic pain and healthy control groups in terms of attentional bias towards pain-related stimuli (i.e. Moses, 1989; Asmundson, Kuperos & Norton, 1997; Asmundson, Wright & Hadjistavropoulos, 2005; Asmundson, Carleton & Ekong, 2005; Roelofs et al., 2005). Specifically, all of these investigations presented general pain word stimuli to participants for 500ms, thus investigating bias during initial orienting of attention only. Based upon the current results, it is therefore likely that these former investigations were not optimally developed to detect bias in chronic pain in the first instance.

### *Emotional Functioning in Chronic Headache*

Between-group comparisons revealed significantly higher levels of depression in individuals with chronic headache than healthy controls in three of the four empirical experiments (i.e. Experiments 2, 3, 4). Such findings are supported by the vast majority

of former studies employing the visual-probe task (i.e. Asmundson et al., 1997; Asmundson, Wright et al., 2005; Asmundson, Carleton et al., 2005; Khatibi et al., 2009) and emotional Stroop task (i.e. Duckworth, Iezzi, Adams & Hale, 1997; Pincus, Fraser & Pearce, 1998; Snider, Asmundson & Wiese, 2000; Beck, Freeman, Shipherd, Hamblen & Lackner, 2001; Andersson & Haldrup, 2003), which also report significantly elevated depression in individuals with chronic pain compared to healthy controls. Although individuals with comorbid clinical depression were excluded from the current programme of research (a practice also specified in many other attentional bias studies), elevated depression was apparent for many individuals with chronic headache. Depression is a serious problem in chronic pain, which has been shown to significantly predict patient disability (Currie & Wang, 2004). Research has also suggested depression to predict the onset of headache (Janke, Holroyd & Romanek, 2004). Treatment of depression is therefore highly important in patients with headache, where “successful headache management is unlikely if comorbid depression is not recognized and effectively treated” (Lipchik & Penzien, 2004. p 96).

High levels of alexithymia have often been reported in chronic pain populations (Lumley, Smith & Longo, 2002). The results of Experiment 3 found significantly elevated alexithymia in individuals with chronic headache compared to healthy controls, a finding also reported by Lioffi et al. (2009). In contrast, Experiments 1, 2, and 4 found no significant differences between groups. The experience of alexithymia in chronic headache therefore varies between individuals, and does not seem as common as depression. Despite this, an understanding of alexithymia in individual patients is likely to be important from a treatment perspective, as variations may affect both patient assessment (Celikel & Saatcioglu, 2006) and the success of different forms of chronic pain treatment (Lumley, Asselin & Norman, 1997).

Aside from evidence of elevated depression and alexithymia, the chronic headache participants recruited in this programme of research did not show any further evidence of emotional distress compared to healthy controls. Although higher levels of anxiety were reported by chronic headache individuals in the four reported investigations, these did not differ significantly from healthy controls in any of the experiments. In contrast, a number of former bias investigations have reported significantly higher anxiety in the chronic pain patients recruited, including Asmundson, Carleton et al. (2005) who recruited individuals with chronic migraine. This may

indicate that levels of anxiety are variable in chronic headache, or that the current research was more stringent in regards to exclusion of participants with evidence of comorbid conditions. Either way, such differences are important to consider when comparing results between investigations. Indeed, the notion that chronic headache individuals in the current programme of research were not distressed to clinically significant levels has a number of theoretical and clinical implications, which shall be discussed below.

### *Correlates of Attentional Bias in Chronic Headache*

Former research investigating attentional bias in chronic pain has found little consistent evidence for underlying correlates of bias. The current research therefore included an in-depth investigation into potential correlates in all four empirical investigations, although little evidence was found to suggest any particular variable underlies bias in this population. Indeed, considering individuals with chronic headache, no significant correlations were found between any of the individual-difference measures utilised and bias towards pain or headache-related images. It therefore appears that bias within such samples is related to the experience of chronic pain itself, as opposed to anxiety, anxiety sensitivity (or fear of pain), depression, alexithymia, rumination, pain acceptance, pain vigilance and awareness, pain self-efficacy, headache disability, or specific coping strategies. Furthermore, bias was not significantly related to pain intensity or chronicity. These findings have implications for theoretical accounts of pain and attention, as discussed below. It is important to note, however, that should the effects of individual difference variables be very small, these are unlikely to have been detected in the current research which recruited small to moderate sample sizes. Finally, even though questionnaire measures failed to correlate with pain bias scores, a decision was made to adopt these in subsequent experiments. As different chronic headache and healthy control samples were recruited for each experiment, it was deemed appropriate to retain all former measures so the characteristics and emotional functioning of each individual sample could be compared.

Although functioning was not correlated with bias for headache or pain images in those with chronic headache, a number of alternative correlations were found. As all of these have been discussed in depth in their respective chapters, only one additional pattern of findings shall be reviewed here. Experiments 2 and 4 both reported a positive

correlation between anxiety (state and trait respectively) and bias towards happy facial expressions in those with chronic headache. This may represent a form of emotion regulation, with individuals with high levels of anxiety choosing to focus upon positive information in an attempt to reduce this anxiety. Self-regulation of emotion has been highlighted as potentially important in chronic pain, and differences in this ability may provide an explanation for the high variability in suffering reported by pain patients (Hamilton, Karoly & Kitzman, 2004). Furthermore, inadequate or maladaptive emotion regulation may be linked to the development of chronic pain conditions (Linton, 2010). Considering this, an understanding of the role of emotion regulation in chronic headache is an important area for future research to explore. While the current research suggests a correlation between anxiety and bias for positive stimuli (i.e. happy facial expressions), it is important to determine the effectiveness of such behaviours in regards to patient functioning.

#### *Similarities and Differences between the Visual-Probe and Emotional Stroop Tasks*

The visual-probe and emotional Stroop tasks have both been commonly used to explore attentional bias in chronic pain, and were both used in the current programme of research. An important question is whether these two paradigms measure the same underlying cognitive process. Brosschot, Ruiter and Kindt (1999) have noted that these two paradigms are likely to measure different stages of information processing. Specifically, the visual-probe presents the critical stimulus after the threat stimulus, while these are presented simultaneously within the Stroop task. It has therefore been argued that biases via the emotional Stroop task may reflect more rapid, automatic attentional processes, while those via the visual-probe may reflect more strategic processes associated with later stages of attentional processing (Brosschot et al, 1999; Johansson, Ghaderi, & Andersson, 2004).

Research addressing this question has investigated bias in a range of populations, and is generally supportive of the view that different processes underlie these paradigms. Asmundson, Wright et al. (2005) utilised both tasks with the same chronic pain and healthy control participant samples. An overall difficulty disengaging from affective pain and health catastrophe words was found via the visual-probe task. In contrast, overall speeded responses were found towards unmasked affective pain words, and masked sensory and health catastrophe words, via the Stroop task. Should both tasks

measure the same phenomena, the difficulty disengaging displayed via the visual-probe task should manifest as interference on the Stroop task. Further to this, no significant correlations were found between bias scores obtained via the unmasked Stroop and visual-probe paradigms. Research investigating bias in both smoking (Mogg & Bradley, 2002) and anxiety (Mogg et al., 2000a) have also reported a lack of significant correlation between bias scores obtained via these two paradigms.

It is important to note that results contradictory to the above have been presented. Egloff and Hock (2003) investigated bias in anxiety, reporting significant correlations between these two paradigms in both subliminal and supraliminal bias scores. These researchers therefore argued for a common underlying mechanism. The current programme of research adopted both paradigms, with neither finding evidence for significant between-group differences for pain, angry, sad, or happy facial expressions. This confirms that, across paradigms, chronic pain patients do not show attentional bias towards such stimuli at early attentional stages. However, the present research cannot be used to directly compare paradigms, as different participant samples were recruited in each investigation. Future research replicating Asmundson, Wright et al. is therefore needed, with the same chronic pain and healthy control samples completing both tasks in a single experimental session.

#### **8.4. Theoretical Implications of the Current Programme of Research**

A number of theoretical models of attention and pain have been proposed. While these models differ in important respects, all support the notion that pain demands attentional resources. This was detailed by Eccleston and Crombez (1999), whose cognitive-affective model has been highly influential in pain research. Of relevance to the current programme of research, the model suggests that chronic pain results in chronic attentional interruption. However, the current results are not deemed supportive of this, as no overall differences in visual-probe or emotional Stroop performance were observed between chronic headache and healthy control groups. Based upon Eccleston and Crombez's model, the former would be predicted to display slower overall response times and increased errors on both visual-probe and emotional Stroop tasks, regardless of emotional content. One explanation is that these paradigms are not demanding enough

of attentional resources, and therefore the presence of pain does not lead to significant interference as attentional capacity is not exceeded. Similar findings have been reported in former attentional bias research (e.g. Lioffi et al., 2009), suggesting that detrimental performance may only be shown when tasks are sufficiently demanding of cognitive resources. Supporting this, chronic pain has been shown to interfere with driving performance (Veldhuijzen, van Wijck et al. 2006), which is arguably more demanding of cognitive resources than visual-probe or emotional Stroop tasks.

Further to the above, additional models of attention and pain not only predict bias towards pain itself, but also towards pain-related information. However, for many of these models, this is the extent of their applicability to the current programme of research. While this section will discuss the current findings in relation to these models as far as possible, it is important to note that none of these models were fully tested by the current research. Pincus and Morley's (2001) Schema Enmeshment Model of Pain (SEMP) is the most relevant model to the current programme of research, specifying a number of important principles regarding the prioritising of information processing. Firstly, it is argued that regardless of content, self-referent information is favoured over other information. Compared to healthy controls, the current programme of research found individuals with chronic headache to bias towards headache images, but not towards pain images. Thus it is possible that only the former are interpreted as self-referent, while expressions of pain alone may not be interpreted in regards to the self (i.e. in the latter thoughts may centre on the model's pain, rather than the participant's own pain). However, a second principle of the SEMP is that information congruent with an individual's self-schema is also preferentially processed. It is difficult to envision how information pertaining to pain would not be part of the self-schema, while that pertaining to chronic headache, which is a form of chronic pain, would be.

The SEMP predicts all individuals with pain to bias towards self-referent sensory pain information. Further to this, this model also predicts patients with current depression to bias towards illness and affective information, while bias towards depressive information (self-referent perceptions of worthlessness) are predicted in patients with both a history of depression and current depression. Although the current programme of research adopted a range of stimuli types corresponding to these categories, individuals with comorbid emotional disorders were excluded from participation. The current research is therefore not ideally suited to test these additional

predictions raised by the SEMP, not was it designed to. However, the evidence for the importance of bias time-course is informative to the SEMP, which does not account for this variable. Overall, it is clear that further testing of the SEMP is necessary, with possible modification to account for the current findings.

Although numerous fear-avoidance models have been proposed, all are supportive of the notion that fearful reactions to pain, pain anticipation, or perceived pain consequences promotes a withdrawal from activities or behaviours believed to increase pain (Norton & Asmundson, 2003). Vlaeyen and Linton's (2000) fear-avoidance model of chronic musculoskeletal pain posits that pain-related fear leads to an increased hypervigilance for bodily signals. Additionally, difficulties disengaging from pain-related information are also predicted. While a number of former studies have provided evidence for this latter relationship (e.g. Khatibi et al., 2009; Asmundson & Hadjistavropoulos, 2007), the majority of studies, including those reported in the current programme, have not. However, fear of pain may itself be linked to a range of pain characteristics, including chronicity, pain intensity, and location. Further research should therefore explore these possibilities, which have implications for fear-avoidance models.

The Misdirected Problem-Solving Model (MPSM; Eccleston & Crombez, 2007) emphasises the role pain-related worries may have upon chronic pain. Among other predictions, of relevance is the notion that pain-related worries result in hypervigilance for pain and pain cues. As a result, attention may become focused upon the task of removing pain. Although the current research did not utilise a specific pain-worry questionnaire, catastrophising was not related to bias for pain or headache information in any investigation. Most recently, a motivational account of attention to pain has been proposed by Van Damme, Legrain, Vogt and Crombez (2010). Noting the inconsistent results for attentional bias in former research, it is argued that motivational factors may underlie bias to pain and pain-related information. Specifically, if an individual's focal goal involves pain management, bias will be enhanced. Within the current research, a number of self-report measures provide an indication of the individual's desire for pain management and control (e.g. the Pain Coping Strategies Questionnaire [CSQ], Rosenstiel & Keefe, 1983; the Chronic Pain Acceptance Questionnaire-Revised [CPAQ], McCracken, Vowles & Eccleston, 2004), although none were found to correlate with bias to pain or headache related information. Thus, for individuals with

chronic headache, bias appears to be related to the experience of pain, rather than motivational goals to manage such pain.

Overall, the majority of theoretical models of attention and pain predict bias towards pain-related information in individuals with pain, a notion supported by the current programme of research. However, unsupported are the propositions that bias results from fear of pain (Vlaeyen and Linton, 2000), pain-related worries (Eccleston & Crombez, 2007), or motivation to remove pain (Van Damme et al., 2010). While the SEMP provides much more detail on bias specificity, the current programme of research is not able to test many of these predictions, which are based upon the existence of current or previous depression and affective distress. Furthermore, of all the accounts discussed, none account for the importance of time-course in attentional bias. However, it is important to note that aside from the SEMP, bias towards pain-related information forms only a small part of these models. For these reasons, the current programme is not sufficient to review these models in depth.

#### *A Theoretical Account of Attentional Bias in Chronic Pain and Pain-Free Individuals*

One implication of the current findings is the need for a new, detailed theoretical account of attention and pain, incorporating evidence presented in the current programme of research, along with former findings into the relationship between attention and pain. A preliminary version of this account is herein presented, although it is important to note that future research is needed to verify this account and to test potential relationships that have yet to be fully explored. Nevertheless, the preliminary account emphasises a number of important concepts. (1) Attention is automatically captured by and directed towards pain, promoting action to be taken (this is adopted from Eccleston and Crombez, [1999], and was not tested in the current programme of research). (2) In individuals with chronic pain, attentional bias is demonstrated towards information personally relevant to the individuals' pain disorder, (3) which is more pronounced during attentional stages associated with maintained attention than initial orienting of attention. (4) Initial orienting bias for general pain-related information may be demonstrated, although due to the lack of disorder specificity, patterns of such bias may not differ between chronic pain and pain-free individuals.

Addressing these concepts in turn, (1) "pain is an evolutionarily acquired alarm signal of bodily threat, and therefore is hardwired to draw attention and interrupt

ongoing goals” (Van Damme et al., 2010, p 206). Pain therefore holds strong survival value (Melzack & Wall, 1996), and all individuals are expected to bias attention towards acute pain. Furthermore, bias towards chronic pain is also expected, although it is important to note that the extent to which both types of pain demand attention depends upon factors such as pain intensity, novelty and predictability, along with individual difference variables (Eccleston & Crombez, 1999). In addition to this bias, (2) individuals with chronic pain direct their attention towards information relevant to their specific pain disorder. Evidence for this comes from the current programme of research (Experiments 1 and 3) and Lioffi et al. (2009), which have found individuals with chronic headache to bias towards headache-related information. Such information is largely irrelevant to pain-free individuals, holding little personal significance. Therefore, bias towards such specific information is not predicted or found in individuals without chronic pain.

For individuals with chronic pain, (3) bias towards disorder-relevant information is more prominent during stages of maintained attention than initial orienting of attention. The results of Experiment 3 and Lioffi et al. (2009) both find significantly greater bias in chronic headache participants at 1250ms when compared to healthy controls. While Experiment 1 found no main effect of presentation time, examination of bias scores revealed stronger bias at 1250ms than 500ms for the chronic headache group, also supporting this notion. This pattern of findings suggests individuals with chronic headache are particularly prone to ruminating or elaborating upon information relevant to their disorder. In contrast, as early, initial processes of attention reflect hypervigilance for threat (Beck et al., 1985), such individuals are less likely to rapidly scan their environment for disorder-relevant information. Furthermore, pictorial and linguistic representations of pain are abstract. While these conceptualise to some degree the experience of pain, they are obviously not as concrete or threatening as pain itself. Such stimuli may therefore require some time to be cognitively processed and identified, thus accounting for the fact that biases are predominately found during later attentional stages associated with maintained attention. However, it is important to add that some evidence of initial orienting of attention towards disorder-relevant information has been found, with bias at 500ms in the chronic headache group significantly greater than 0 in Experiment 3 (although not in Experiment 1). Overall, disorder-specific bias in chronic pain is more robust to information presented for

1250ms, supporting the notion that bias at this stage is likely to reflect elaborative processes (Donaldson et al., 2007).

Evidence of an initial orienting bias for general pain information is mixed (4), although may be demonstrated by certain individuals regardless of pain state. The meta-analysis presented in Study 1 provides some evidence that patients with chronic pain bias towards such information relative to healthy controls (although one study included in this analysis [i.e. Lioffi et al., 2009] used disorder-specific words). Considering healthy samples, some research is suggestive that variables such as fear of pain (Keogh, Ellery, Hunt & Hannent, 2001), anxiety sensitivity (Keogh, Dillon, Georgiou & Hunt, 2001) and threat expectancy (Boston & Sharpe, 2005) influence bias for general pain information. However, not all research is supportive of this (i.e. Keogh & Cochrane, 2002; Roelofs, Peters, van der Zijden, Thielen & Vlaeyen, 2003; Keogh, Thompson & Hannent, 2003). Likewise, the current programme of research found no evidence to suggest healthy controls bias towards general pain information, while Khatibi et al. (2009) suggest healthy controls bias *away* from this information. In the current theoretical model, this concept (4) is therefore only partially supported by empirical research. However, it is important that this concept is not ignored. Future research is clearly needed addressing this issue, along with variables that may underlie initial orienting bias towards general pain information.

#### *Directions for Future Research*

The theoretical account presented attempts to clarify the specificity and time-course of bias towards pain-related information in both chronic pain and pain-free individuals. However, as noted this account is preliminary in nature, and further research is needed for its verification. Firstly, the prediction that individuals with chronic pain bias towards disorder relevant information is based upon research with chronic headache. It is therefore important for future research to test this prediction with other chronic pain samples. Secondly, evidence of bias towards general pain information is mixed, although individual-difference variables appear to be important with pain-free individuals. Consistent evidence for the importance of such variables has not been found in chronic pain, with clarification needed in both accounts. Thirdly, the precise relationship between bias during attentional stages of initial orienting and maintained attention is unclear. Although correlational analysis of 500 and 1250ms bias scores

could have been conducted in the current programme of research, a limitation of this method is that it implies a direct relationship between these two stages that may not exist. For example, a significant positive correlation could indicate that attentional fixation upon pain stimuli at 500ms is retained through to 1250ms. However, it is equally possible that attention may shift away from the pain stimulus, and subsequently return. This difficulty in interpretation is likely the reason why the majority of former studies investigating bias time-course in anxiety have not used this form of analysis (e.g. Mogg, Bradley, De Bono & Painter, 1997; Mogg & Bradley, 2006). As discussed below, the use of eye-tracking technology overcomes this limitation, and is the next feasible step for research investigating the time-course of bias in chronic pain to take.

#### *Potential Explanations for Attentional Bias in Chronic Headache*

A notable feature of many chronic pain disorders, including primary chronic headache, is the lack of adaptive value of such pain (Ridson, Eccleston, Crombez, & McCracken, 2003). Considering this, an important question arising from the current programme of research is *why* individuals with chronic headache bias towards headache-related information, and whether it is adaptive or maladaptive effects. In humans, facial expressions serve important social functions (Schmidt & Cohn, 2001; Goren & Wilson, 2006). Facial expressions of pain are likely to serve multiple functions, potentially eliciting help from others or providing a warning of potential danger in the environment (Williams, 2002). As the headache-related images used in Experiments 1 and 3 featured facial expressions of pain, these are likely to portray such messages. However, the additional content (i.e. placement of hands on the head) emphasises the head as the location of pain, with the model most likely interpreted as experiencing headache. An individual engaging in such behaviour may therefore present the message that potential danger in the environment has caused their head pain. Due to the frequent and often intense nature of chronic headache, patients may be particularly prone to avoiding situations, events or items that are believed to trigger headache. Evidence for the high number of reported triggers has been shown in chronic headache (Kelman, 2007), as has the adoption of avoidance as a coping strategy (Norton & Asmundson, 2004; Radat et al., 2008). Individuals with chronic headache may therefore be attentive towards others with headache in an attempt to anticipate or reduce the impact of potential environmental headache triggers.

Alternatively, bias may be displayed because individuals with headache empathise with others experiencing the same medical complaint. In this instance, the individual may be reminded of their own medical condition, leading to rumination. This process may have negative consequences, however, as viewing emotional expressions has been shown to trigger the experience of similar emotions in the viewer (Wild, Erb & Bartels, 2001). As pain is both a sensory and emotional experience (International Association for the Study of Pain [IASP], 1979), viewing another person in pain may elicit similar emotional responses (Chapman & Nakamura, 2002). Furthermore, Loggia, Mogil and Bushnell (2008) have provided evidence that empathy affects pain perception. Participants were required to watch a video designed to induce either high or low empathy for an actor (who was said to be another participant). Heat stimuli (both painful and non-painful) were then administered, while the participant watched a video of the same actor receiving the same stimuli. Participants induced to high empathy reported their pain as significantly more intense ( $p = .01$ ) and unpleasant ( $p < .01$ ) than those induced to low empathy. Empathy for others experiencing headache may therefore underlie the pattern of bias observed in those with chronic headache. However, it is important for future research to investigate this specifically, and also to address whether bias is linked to patient functioning across time.

### **8.5. Clinical Implications of the Current Programme of Research**

Consistent evidence for attentional bias has been provided in chronic headache (Lioffi et al., 2009; Experiment 1; Experiment 3), with a number of clinical implications likely to exist. Firstly, pain itself demands attentional resources (Eccleston & Crombez, 1999), which humans possess in limited quantities (Styles, 2006). As a result of such demands, detrimental effects have been commonly found in attention-demanding tasks (e.g. Kuhajda, Thorn, Klinger & Rubin, 2002; Veldhuijzen, van Wijck, et al., 2006). As attentional bias also demands a portion of an individual's cognitive resources, even greater load is placed upon the patient with chronic pain. An individual with chronic headache who demonstrates attentional bias may therefore be particularly vulnerable to experiencing detrimental effects in cognitive performance. Future research investigating the implications of attentional bias in chronic pain is needed, with no published research

to date considering this. However, investigating recall bias in 63 patients with lower back pain, Pincus and Newman (2001) found bias for pain descriptors to be a significant predictor of patient health-care cost. Evidence therefore supports the notion that cognitive biases in chronic pain are linked to patient functioning, although it is important to add that causality remains unknown.

Considering the above, patients with attentional bias may be appropriate targets for psychological interventions such as cognitive behavioural therapy (CBT). CBT is commonly used in pain management programmes (Gatchel & Rollings, 2008), although more appropriate targeting of interventions may be achieved through an understanding of any biases patients' may hold. Supporting this, Pincus and Morley (2001) have noted that paradigms measuring bias in information-processing may be of clinical use, identifying patients who would benefit from psychological interventions, and may also be used to test patient relapse. While such implications have not been specifically addressed, Dehghani, Sharpe and Nicholas (2004) found participation in a CBT programme designed to reduce pain-related fears resulted in a significant decrease in attentional bias towards sensory pain stimuli in a sample of chronic musculoskeletal pain patients. As these researchers used the visual-probe task, support is therefore provided for the clinical implementation of this particular paradigm. Recently, research has considered the benefits of modifying cognitive bias in anxiety disorders (Steel et al., 2010). Using the visual-probe task, Amir, Beard, Burns, & Bomyea (2009) reported significant reductions in both attentional bias and anxiety in individuals with generalised anxiety disorder following an attention modification programme. Cognitive bias modification has therefore shown positive results in anxiety disorders, although it is important for researchers to extend such programmes to other disorders (MacLeod, Koster & Fox, 2009). Considering the results presented in this doctoral thesis, it would be timely for future research to consider the potential benefits of such programmes in relation to chronic pain. In this regards, paradigms such as the visual-probe task may have clinical benefits in not only highlighting potential patients for clinical intervention as suggested by Pincus and Morley (2001), but also in intervention programmes themselves.

Should cognitive paradigms be used in future chronic pain interventions, the question arises as to how the current results may inform such programmes. Firstly, the evidence of bias specificity found suggests the use of specific pain stimuli is likely to be

of greater benefit than more generalised stimuli. Thus, there would be a need for different stimuli sets to be developed representative of different chronic pain conditions. Secondly, the use of multiple stimuli presentation times associated with initial orienting of attention and maintained attention is of importance, as bias has been found to be more pronounced during the latter than the former. The time-course of bias may also yield important information for clinicians, as interventions appropriate for hypervigilance for threat are likely to differ from those that are appropriate for difficulty disengaging from threat (Asmundson, Wright et al., 2005). According to McNally (1995, p 747), “to the extent that biases are automatic, they may be difficult to correct by strategic means, such as verbal psychotherapy”.

Overall, there are notable clinical implications of the current research, although further investigation is necessary to fully understand these implications in regards to both chronic headache and other chronic pain conditions. With the exception of a few key studies (i.e. Pincus & Newman, 2001; Dehghani et al., 2004), little published research has explored this area. However, the consistent evidence that now exists for attentional bias in chronic headache may encourage other researchers to investigate this area. Psychological interventions are considered fundamental in many chronic pain treatment programmes (McGrath & Holahan, 2003; Hoffman, Papas, Chatkoff & Kerns, 2007). Cognitive paradigms that may assist in such programmes are of potential benefit, and may have worth as tools in clinical settings. Recent research into cognitive bias modification in anxiety has provided supportive evidence for paradigms such as the visual-probe task in regards to patient outcome (MacLeod et al., 2009), and therefore the use of these in chronic pain disorders is an important step for future research to take.

## **8.6. Limitations of the Current Research**

The research presented in this doctoral thesis aimed to overcome a number of limitations highlighted in past research, including problems associated with recruitment of heterogeneous pain samples, the lack of disorder-relevant pain stimuli, the lack of investigation into bias time-course, and specific methodological issues associated with the visual-probe paradigm. Despite these improvements in methodological rigour, a

number of limitations are notable in the current programme of research. Firstly, individuals with both chronic tension-type headache and chronic migraine were recruited for all four experiments. As an aim of this research was to investigate bias specificity, an alternative option would have been to recruit individuals with a single headache disorder only. However, recruiting individuals with different chronic headache subtypes is a common practice (e.g. Scher, Stewart, Ricci & Lipton, 2003; Wang, Wang, Chang & Lin, 2007), where in many instances patients are referred to as having Chronic Daily Headache (CDH). CDH refers to the experience of 15 or more headache days per month regardless of the precise headache subtype. However, as CDH can include headaches stemming from medication overuse (Silberstein, 2005), this term was not applied in the current thesis, as medication overuse was an adopted exclusion criterion.

Furthermore, it is likely that the stimuli utilised in the current research were of equal relevance to all headache participants regardless of headache type. Headache-related image sets employed in Experiments 1 and 3 were specifically developed to convey the prototypical experience of headache. Common responses to pain include holding or touching the affected body part (Koho, Aho, Watson, & Hurri, 2001). Images of models holding their heads, while simultaneously portraying a facial expression of pain, therefore reflect a typical reaction to headache, which is likely to be of equal relevance to individuals with tension-headache and migraine. Additionally, while it is true that these two headache subtypes can differ in precise head-pain location, intensity, and other pain characteristics, variation is also seen within these subtypes (International Classification of Headache Disorders (ICHD) -II, 2004). For these reasons, separate pictorial stimuli sets for these headache subtypes were not utilised, and may not even be practically possible to develop.

Based upon theories of emotional processing (e.g. Wells and Matthews, 1994; 1996; Bower, 1981), a decision was made to investigate bias in a specific pain sample. However, a limitation of this decision is that caution must be taken when applying the results of Experiments 1 to 4 to chronic pain populations other than chronic headache. One possibility would have been for the current research to explore bias in alternative pain populations. In defence of methodology adopted, was important for the current thesis to fully examine bias in chronic headache, addressing the numerous questions which remained unanswered from the results of former research, and also those that arose during the course of this programme of research itself. Therefore, rather than

providing a vague understanding of bias across differing chronic pain conditions, it was deemed more appropriate to provide a detailed understanding of bias in a single chronic pain condition. However, difficulties generalising the results obtained has implications for the theoretical model proposed, which is currently largely applicable to chronic headache only. As noted, further testing is required with this model, which is preliminary in nature.

Although the current programme of research investigated the time-course of attentional bias, a further limitation may be the inclusion of only two stimuli presentation times (i.e. 500 and 1250ms) across Experiments 1 to 3. Bias towards subliminally presented stimuli have not been investigated in adult chronic pain samples, although Boyer et al (2006) found children with recurrent abdominal pain to show significant bias towards pain words presented subliminally for 20ms, and significant avoidance of such stimuli presented supraliminally for 1250ms. While subliminal attention is non-conscious and automatic, supraliminal attention is conscious and under voluntary control (Shiffrin & Schneider, 1977). The current programme of research therefore provides no information on subliminal processing in chronic headache, although an understanding of whether such individuals also show bias towards subliminally presented pain stimuli is of importance to the development of a theoretical account of attentional bias in pain. Furthermore, it may have also been of advantage to employ longer stimuli presentation times to acquire an understanding of how long individuals with chronic pain maintain their attention upon relevant pain stimuli. However, increasing the number of stimuli presentation time conditions would have substantially increased both experimental duration and participant burden (Kellough, Beevers, Ellis, & Wells, 2008). It is also likely that resulting participant fatigue would have affected response times during such a lengthy computer task. Due to these considerations, the inclusion of additional presentation times was decided against.

Related to the above, the current research adopted a stimuli presentation time of 500ms as a measure of initial orienting of visual attention in the visual-probe task. Supporting this, Bradley et al. (2000) have provided evidence that bias for threat at 500ms reflects the initial saccadic eye movement. The term ‘initial orienting’ has also been adopted by others to reflect bias at this presentation time (e.g. Mogg, Miller, & Bradley, 2000; Mogg, Bradley, Field & De Houwer, 2002; Gamble & Rapee, 2009). However, an alternative possibility is that during the 500ms presentation, participants

may instead shift initial attention towards the neutral stimulus, and then orient towards the threatening stimulus. Cooper and Langton (2006) have suggested that bias at 500ms is not indicative of initial orienting of attention. Although there is uncertainty concerning this issue, the term ‘initial orienting’ was adopted in the current thesis to represent early attentional processes, while ‘maintained attention’ (i.e. bias at 1250ms) was adopted to represent later processes. Together, these are deemed representative of contemporary views of the attentional system (e.g. Allport, 1989; LaBerge, 1995), which highlight the need for both quick shifting of attention, and sustained attention. However, a limitation of the current research is that it remains unknown whether bias at 500ms reflects the initial saccadic eye-movement towards threat, with future eye-tracking research needed to verify this. Despite this, ‘initial orienting’ was deemed more appropriate than alternatives. ‘Hypervigilance’ has been commonly used in this field, which can be defined as “a behavior involving enhanced or exaggerated search of environmental stimuli or scan for threatening information” (Rollman, 2009. p. 183). However, Rollman has noted that this term is often used to describe the phenomenon of reduced pain threshold and pain tolerance shown in some medical syndromes. ‘Initial orienting’, alternatively, has been exclusively used in the literature to refer to processes of visual attention. Another commonly used term is ‘vigilance’, although this term has been broadly used by researchers, and may refer to both conscious and unconscious processes (Reber & Reber, 2001). For these reasons, ‘initial orienting’ was deemed the most appropriate term, and therefore applied in the current thesis.

In all four experiments, individuals with chronic headache were recruited from the community, responding to announcements placed in various newspapers, publications, and posters. A limitation of this recruitment method, however, is that individuals responding to these advertisements may possess different characteristics from non-responders. Considering chronic headache, individuals who are severely disabled by their condition may be less inclined to contact the researcher than individuals who are less disabled. Alternatively, responders may have been more motivated to take part in the research programme, despite the lack of direct benefits to their person. Supporting this, a number of participants emphasised personal fulfilment in the knowledge that their participation may help researchers and clinicians to understand chronic headache to a better degree. From the methodology adopted, it remains unknown as to whether responders differed in any significant way from non-responders,

in terms of headache characteristics or emotional functioning. As a result, the participants recruited may not be representative of the chronic headache population as a whole. However, this limitation is not exclusive to the current programme of research, as no former investigation in this field has satisfactorily addressed this issue.

As noted, all participants with chronic headache in this programme of research were recruited from the community. While ethical approval was obtained from the National Health Service (NHS) to recruit patients from Southampton General Hospital for Experiment 3, a local neurologist who agreed to refer patients subsequently left the country. As no remaining neurologists specialised in headache disorders, no patient referrals were made from the NHS. The current sample may therefore not be representative of patients with chronic headache referred from neurologists, and thus generalising these results to all patients with chronic headache may be problematic. However, all patients in this course of research had visited their GP in regards to their headaches, with the vast majority also referred to a neurologist at least once to confirm no underlying disease or structural damage was causing their headache (i.e. secondary headaches). Furthermore, the samples recruited in each experiment are typically representative of the chronic headache population in terms of gender ratio (i.e. more prevalent in females) and age of headache onset (Jensen & Stovner, 2008). The individuals recruited therefore share a number of similarities with the general headache population. However, due to exclusion of individuals with comorbid physical and emotional disorders (which are common in individuals with headache; Midgette & Scher, 2009), individuals recruited for the current research may have been less disabled and suffered less emotional distress than that typically reported. To increase validity of results, these exclusion criteria were necessary however.

A final limitation with the current research is the fact that in all experiments, attentional bias was only investigated in one experimental session. While evidence for the reliability of the visual-probe task to detect bias in chronic headache has been found, no information pertaining to the development or maintenance of bias across time was provided. To date, only one longitudinal study has been conducted in this area (Dehghani, Sharpe & Nicholas, 2004), investigating the modification of bias through a CBT programme. However, a limitation with this study was the lack of control group not receiving the CBT intervention. Further longitudinal research is of advantage, providing information on the stability of bias across time. Related to this, the evidence

of bias found in the chronic headache group provides no indication of causality. It is possible that attentional bias may result from the experience of pain, leading patients to focus and ruminate upon relevant pain-related information. Alternatively, bias for such information may play a role in the aetiology or maintenance of chronic pain. For example, patients with bias may be more conscious of somatic feelings, and therefore interpret relatively mild or harmless symptoms as painful or threatening. Once again, the necessity of longitudinal research is highlighted.

### **8.7. Suggestions for Future Research**

Throughout this thesis, numerous possibilities for future research have been noted, including the investigation of attentional bias specificity in alternative chronic pain disorders, the modification of bias via interventions such as CBT, the use of paradigms such as the visual-probe task in clinical settings, the role of emotion regulation in chronic headache, and the implementation of longitudinal research to explore issues of bias and pain causality. In addition, a number of further possibilities exist, which shall now be discussed in detail.

#### *Eye-Tracking Technology*

Perhaps the most pertinent possibility for future research involves the implementation of eye-tracking technology to further explore attentional bias in chronic pain. Eye-tracking has been extensively used in cognitive psychology, which over the past decade has been increasingly used to explore processes of attention in anxiety disorders. Such technology allows for the recording of the pattern, orientation, and duration of eye movements (Kimble et al., 2010), with the ability to distinguish spatial and temporal aspect of visual attention an advantage (Derakshan, Salt & Koster, 2009). A limitation of the visual-probe task is that it only captures a snapshot of attention for each stimuli exposure duration utilised (Mogg & Bradley, 2005), with no information gathered regarding attention before or after the onset of the visual-probe (Cooper & Langton, 2006). Thus, it remains unknown how quickly individuals with chronic headache orient their attention towards pain-related information, or how long they continue to focus or dwell upon such information. As discussed above, increasing the

number of stimuli presentation times in a single experiment substantially increases participant burden (Kellough et al., 2008). Thus, the use of eye-tracking technology provides a viable solution, continuously measuring attention across both initial orienting and maintained stages of attention. Indeed, it has been argued that eye-tracking technology is ideally suited for research investigating attentional bias (Eizenmann et al., 2003). To date, no published research has implemented eye-tracking technology in this field of research, which represents the next logical step in investigating the time-course of attentional bias in chronic pain.

Similar to the visual-probe task, the emotional Stroop task is also limited in that it too only measures a snapshot of attention (Mogg & Bradley, 2005). Furthermore, it has been argued that interference effects may result from either a bias towards emotionally arousing stimuli, or an avoidance of such stimuli (de Ruiter & Brosschot, 1994). Thus, as delayed response times may result from a number of different processes, the eye-tracking technology would also be beneficial with the emotional Stroop task. Although Experiment 4 reported no evidence of significant bias via this paradigm, participants with chronic headache may have still demonstrated a different pattern of attention to healthy controls. For example, those with headache may have used covert attention to determine the colour of pain images should they be emotionally arousing. Eye-tracking methodology provides the only feasible way to investigate possibilities such as these.

A further area for future research involves the use of experimental paradigms other than the visual-probe and emotional Stroop tasks, including the commonly used visual-search task. In one particular version, participants must locate a specific emotional expression embedded among a number of distractor expressions, which may themselves be either neutral or of alternative emotional expressions (Calvo, Nummenmaa & Avero, 2008). Such paradigms have often been administered to individuals with emotional disorders (e.g. Rinck, Becker, Beckermann & Roth, 2003; Matsumoto, 2010), although have yet to be implemented with chronic pain populations. Like the visual-probe task, visual-search tasks can be used to determine whether certain populations display attentional biases towards relevant information via an examination of response times. However, visual-search tasks possess the advantage of being able to investigate the strength of bias in the presence of an increasing amount of distractors. Specifically, the efficiency of participant search can be established via the plotting of

response-times across distractor conditions. If a particular group displays an automatic attentional bias, this is expected to become more apparent with larger numbers of distractors (Eastwood et al., 2005). Once again, eye-tracking technology is advantageous with this paradigm, providing fine-detailed information on processes of initial orienting and attentional rumination.

### *Attentional Control in Chronic Pain*

The relationship between attentional bias in chronic pain and processes of executive control has rarely been explored in former research. Experiment 4 provided an initial investigation into this relationship, exploring spontaneous and reflective flexibility. However, further research is needed into alternative processes of executive control. One such process, attentional control, refers to the success to which individuals are able to focus or shift their attention when desired (Moriya & Tanno, 2008), including the ability to inhibit attention and thoughts from orienting automatically towards a stimulus. Measures of attentional bias, including visual-probe and emotional Stroop tasks, require a degree of attentional control, requiring participants to shift attention away from task-irrelevant information and towards task-relevant information (i.e. visual-probe and stimulus colour respectively). Despite this, former research exploring bias in chronic pain has failed to consider whether deficits in attentional control underlie such bias. One possibility is that poor attentional control may manifest in bias towards pain-related information. In contrast, high attentional control may result in either no attentional bias being observed, or an attentional avoidance of such information. Within the visual-probe task, participants are required to indicate the location of a probe, which appears randomly in one of two possible locations. Thus, task requirements may encourage participants to monitor both locations in the display relatively equally. However, only individuals with high attentional control may be able to adhere to this attentional style, while those with low control may be more prone to display bias. An investigation of the relationship between attentional control and attentional bias is therefore warranted. Supporting this, Derryberry and Reed (2002) have provided evidence for the moderating role of attentional control in bias towards threat in individuals with high anxiety.

In order to explore attentional control in chronic pain, the antisaccade task may be utilised in future research. Developed by Hallett (1978), the antisaccade task has been

used in a wide-range of research investigating executive functioning and attentional control in different psychiatric and neurological patient populations (Hutton & Ettinger, 2006). During this task, the individual is presented with an initial central fixation point, which is then replaced by an onset target (e.g. an asterisk) to either the left or right. The task of the participant is to refrain from focusing upon this target, but instead to direct their visual attention to the opposite, mirror location. Correct performance requires the suppression of the automatic tendency to fixate upon the target, along with the performance of a voluntary motor command to look in the mirror location (Munoz & Everling, 2004). Eye-tracking technology is used with this task to record participant performance. Due to the demands of pain upon attentional and cognitive resources (Grisart & Plaghki, 1999), individuals with chronic pain may display poorer levels of attentional control than pain-free controls. Additionally, an exploration of the relationship between attentional control and attentional bias may be achieved via the implementation of an antisaccade task featuring emotional facial stimuli (e.g. painful, angry, happy, sad and neutral expressions) as peripheral cues. Recent research has provided evidence of greater difficulties inhibiting the automatic, reflexive saccade when the peripheral cue represents the individual's fears or concerns (Derakshan et al., 2009).

### *Neuroimaging and Attentional Bias in Chronic Pain*

Neuroimaging techniques have been increasingly used to explore cortical areas associated with the processing of pain (Chen, 2002). Methods such as electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) have been commonly adopted in such investigations, offering a non-invasive method of exploring pain, and the factors which influence it (Tracey & Mantyh, 2007). As discussed in Chapter 1, pain is processed in a variety of cortical regions referred to as the pain matrix, including the primary and secondary somatosensory cortices, the prefrontal cortex, the anterior cingulate cortex (ACC) and the amygdala, among others (Moisset & Bouhassira, 2007; Tracey & Mantyh, 2007). Importantly, a number of these areas have also been implicated in processes of attentional bias, including the amygdala in vigilance towards threat (Davis & Whalen, 2001; Öhman, 2005). Reviewing the literature, Cisler & Koster (2010) also note that areas such as the prefrontal cortex and anterior cingulate cortex (ACC) may be involved in difficulties in disengaging from threat. Such cortical

overlap provides a neurological explanation for the cognitive modulation of pain that has been reported in numerous studies (e.g. Kleiber & Harper, 1999; Johnson & Petrie, 1997). Despite this overlap, research has yet to specifically investigate underlying cortical activity in chronic pain attentional bias. One method of achieving this is through the investigation of event-related potentials (ERPs), which provides useful information on the timing of cognitive events (Eysenck & Keane, 2000). Such methodology has been employed by researchers exploring attentional bias in anxiety disorders. As stated by Bar-Haim, Lamy & Glickman (2005, p. 13),

“Recording of ERPs to cue and target stimuli may provide useful data on both the timing and the neural substrates of spatial attention. Such physiological data may serve as converging operations that supplement behavioral data to advance our understanding of the mechanisms underlying attentional biases in anxiety.”

The recording of ERPs in patients with chronic pain performing concurrent attentional bias tasks is likely to be highly informative. Specifically, neuroimaging tools such as EEG may add further information regarding the time-course of bias, as different components of the ERP have been linked to different processes of attention. Onset of attention has been linked to P100 and N200 components, while P300 and N400 have been linked to later stages of processing (Sass et al., 2010). The recording of ERPs, which provide data on a millisecond by millisecond basis, would therefore compliment data gathered from the visual-probe or emotional Stroop task, which only capture a snapshot of attention. Furthermore, research has suggested that processing of pain-related words engage different cortical areas to neutral and other emotional words (e.g. Flor, Knost & Birbaumer, 1997; Sitges et al., 2007). Further research investigating this area is needed however, including the use of pictorial stimuli such as facial expressions of pain.

Compared to EEG, fMRI has been less frequently used to explore processes of attentional bias, a factor likely attributable to its poorer temporal resolution, which is in the order of several seconds. Although this technique cannot be reliably used in determining the time-course of attentional bias, it may have applications in determining the cortical structures underlying bias, as the spatial resolution is much greater than that produced by EEG (Eysenck & Keane, 2000). Indeed, research has suggested that neural

mechanisms involved in orienting of attention vary to some degree depending upon the emotional content of the stimuli used (e.g. Pourtois, Schwartz, Seghier, Lazeyras & Vuilleumier, 2006). Thus, the use of fMRI in future research would clarify the results found in the current programme of research. Specifically, between-group bias differences were only found with highly relevant headache stimuli, and not with facial expressions of pain. fMRI would be able to clarify whether different neural mechanisms are involved in the processing of these two different forms of stimuli.

Furthermore, fMRI could also be used to identify precise cortical areas that are involved in both the processing of chronic headache pain specifically, and also in attentional bias. Although the pain matrix is implicated in the processing of pain, the precise cortical regions involved varies to some degree. There has been little research into chronic pain, although it has been noted that the traditional concept of the pain matrix may be more applicable to acute pain than chronic pain (Baliki et al., 2006; Tracey & Mantyh, 2007). This is an important line of investigation, and may provide information on potential consequences of attentional bias. For individuals with chronic pain, repeated attentional bias towards pain-related information may serve to increase subjective perceptions of one's own pain. While this has not been specifically addressed in former research, evidence is suggestive that viewing others in pain activates cortical areas also involved in the processing of one's own pain, including the ACC and anterior insula (e.g. Singer et al., 2004; Jackson, Meltzoff & Decety, 2005). Furthermore, research has also suggested that empathy for others' pain increases perceptions of both pain intensity and unpleasantness in oneself (Loggia et al., 2008). Future research examining the relationship between bias for pain-related information and subjective perceptions of pain is clearly needed, which may have clinical implications. The use of fMRI would be of benefit in such research, where evidence of cortical overlap would provide a neural-based explanation for any such effects.

## **8.8. Conclusions**

The main aim of this programme of research has been to determine whether individuals with chronic pain demonstrate attentional bias towards information related to pain. Based upon theoretical models of emotional processing, and models of attention

and pain, biases in chronic pain were predicted relative to healthy, pain-free controls. Support for this prediction has been provided through a meta-analysis of former research, and also through a series of empirical investigations utilising the visual-probe task. Further to this, the current research also sought to address both the specificity and time-course of bias. In order to achieve this, a specific chronic pain population was selected for investigation; chronic headache. Bias in individuals with chronic headache has been reliability found towards pictorial, disorder-relevant headache information, at attentional stages associated with both initial orienting of attention and maintained attention. However, supporting the former results of Lioffi et al. (2009), this bias is more pronounced during the later stage, which is likely to reflect excessive elaboration or rumination over stimuli. A final aim was to provide information on underlying correlates of bias in chronic pain, although little supportive evidence for the importance of any particular variable has been found, warranting further investigation.

The results from this research have been argued to possess both theoretical and clinical implications. Considering the former, current models of attention and pain are limited in that none adequately account for either the specificity or time-course of bias observed in the current research. A preliminary model detailing these findings has therefore been presented, which will need further research to verify and test the predictions it presents. Clinical implications centre on the notion that bias in chronic pain may be predictive of patient functioning, although little research has to date specifically investigated this possibility. However, it is possible that modification of attentional bias may have beneficial outcomes for patients, and is therefore worthy of investigation. A limitation of paradigms such as the visual-probe and emotional Stroop tasks is that these only capture a snapshot of attention. While numerous additional avenues for further investigation have been presented, the use of eye-tracking technology is the most pertinent, and represents the next logical step for investigating patterns of attentional bias in chronic pain.

## Appendices

### Appendix A – Study 1

Table A.1

*Table and criteria used for assessment of methodological quality in the five studies included in the meta-analysis*

	Asmundson, Carleton et al. (2005)	Asmundson, Wright et al. (2005)	Khatibi et al. (2009)	Lioffi et al. (2009)	Roelofs et al. (2005)
Inclusion criteria					
Exclusion criteria					
Types of patients					
Matching controls					
Matching stimuli					
Environment					
Depression					
Anxiety					
Pain-related fear					
Statistical analysis					
<b>Total</b>					

*Inclusion criteria for the assessment of methodological quality*

1. Were the inclusion criteria for both pain and control groups specified?
2. Were the exclusion criteria for both pain and control groups specified?
3. Were the types of pain patients specified?
4. Were control and pain participants matched on age, gender, and education level?
5. Did controls share the same testing environment?
6. Were experimental (pain-related) and control stimuli matched?
7. Were levels of depression adequately assessed?
8. Were levels of anxiety adequately assessed?
9. Were levels of pain-related fear or anxiety adequately assessed?
10. Was the statistical analysis appropriate?

Yes= 1

No/ Don't know = 0

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This assessment of methodological quality was based upon that utilised by Roelofs, Peters, Zeegers & Vlaeyen (2002)

## Appendix B – Experiment 1

Table B.1

*Ratings of emotional content (SD) for headache-related and neutral images from preliminary experiment A*

Stimuli	Happy	Sad	Angry	In Pain	Frustrated
Headache-Related (Experimental)	1.64 (.59)	4.16 (1.64)	3.74 (.92)	7.57 (.51)	4.47 (.57)
Neutral (Experimental)	2.44 (.64)	3.23 (.88)	3.05 (1.05)	2.56 (.71)	3.74 (.91)
Neutral A (Control)	2.79 (.90)	3.63 (.73)	3.41 (.82)	2.81 (.61)	4.03 (1.19)
Neutral B (Control)	3.02 (.95)	3.38 (.92)	2.93 (1.32)	2.61 (.92)	3.40 (1.04)

Table B.2

*SAM ratings of valence and arousal (SD) for headache-related and neutral stimuli from preliminary experiment B*

Stimuli	Valance	Arousal
Headache-Related (Experimental)	4.17 (.39)	3.33 (.49)
Neutral (Experimental)	4.83 (.39)	2.83 (.58)
Neutral A (Control)	5.08 (.29)	3.00 (.43)
Neutral B (Control)	5.08 (.29)	2.92 (.29)

Table B.3

*Cronbach's Alphas for the self-report measures utilised in Experiment 1*

Measure	Cronbach's Alpha
ASI	.852
MBSS monitoring	.517
MBSS blunting	.557
STAI state	.945
STAI trait	.926
TAS-20 total	.839
TAS-20 - DIE	.855
TAS-20 - DDE	.778
TAS-20 – EOT	.554
HADS anxiety	.847
HADS depression	.756
CPAQ total	.806
CPAQ willingness	.820
CPAQ activities	.776
CSQ-Total	.876
Dividing attention CSQ	.913
Reinterpretation CSQ	.784
Catastrophising CSQ	.775
Ignoring CSQ	.902
Praying CSQ	.574
Coping self-statements CSQ	.790
IBA CSQ	.790
MPQ-SF sensory	.450
MPQ-SF affective	.754
MPQ-SF total (sensory + affective)	.627
PSEQ	.920

Table B.4

*Correlations between self-report measures, headache chronicity and attentional bias scores for chronic headache participants (n= 17)*

Measure	500ms Bias	1250ms Bias
ASI	.413	-.035
STAI state	.130	-.328
STAI trait	.205	-.259
TAS-20 total	-.007	-.057
TAS-20 - DIE	-.005	-.249
TAS-20 - DDE	.193	-.046
HADS anxiety	.186	-.217
HADS depression	.49	-.347
CPAQ total	-.248	.345
CPAQ willingness	-.160	.129
CPAQ activities	-.295	.504
Dividing attention CSQ	-.315	-.503
Reinterpretation CSQ	.025	-.221
Catastrophising CSQ	.169	-.329
Ignoring CSQ	.181	.178
Coping CSQ	-.181	-.209
IBA CSQ	.258	-.099
Control CSQ	.077	.287
Decrease CSQ	.014	.430
MPQ-SF sensory	.251	-.049
MPQ-SF current pain	.299	.128
MPQ-SF overall pain	-.014	-.449
PSEQ	-.282	.110
Headache chronicity (in months)	-.163	.043

\* Correlation is significant at the .01 level

Table B.5

*Correlations between self-report measures and attentional bias scores for healthy control participants (n= 21)*

Measure	500ms Bias	1250ms Bias
ASI	.106	-.013
STAI state	-.056	-.094
STAI trait	.019	.042
TAS-20 total	.077	.181
TAS-20 - DIE	.232	.293
TAS-20 - DDE	-.190	-.076
HADS anxiety	.128	-.039
HADS depression	.076	.026

\* Correlation is significant at the .01 level

Table B.6

*Correlations between self-report measures and attentional bias scores for all participants experimental and control combined (N= 38)*

Measure	500ms Bias	1250ms Bias
ASI	.282	.013
STAI state	.084	-.129
STAI trait	.179	-.028
TAS-20 total	.033	.071
TAS-20 - DIE	.127	.078
TAS-20 - DDE	-.019	-.086
HADS anxiety	.223	-.024
HADS depression	.115	-.063

\* Correlation is significant at the .01 level

## Appendix C – Experiment 2

Table C.1

*Cronbach's Alphas for the self-report measures utilised in Experiment 2*

Measure	Cronbach's Alpha
ASI	.894
MBSS monitoring	.627
MBSS blunting	.442
STAI state	.931
STAI trait	.940
TAS-20 total	.854
TAS-20 - DIE	.852
TAS-20 - DDE	.839
TAS-20 – EOT	.496
HADS anxiety	.873
HADS depression	.849
CPAQ Total	.916
CPAQ willingness	.848
CPAQ activities	.849
CSQ-total	.825
Dividing attention CSQ	.714
Reinterpretation CSQ	.798
Catastrophising CSQ	.820
Ignoring CSQ	.830
Praying CSQ	.867
Coping CSQ	.865
IBA CSQ	.763
MPQ-SF sensory	.742
MPQ-SF affective	.745
MPQ-SF total (sensory + affective)	.824
PSEQ	.917

Table C.2

*Correlations between self-report measures, headache chronicity and attentional bias scores for chronic headache participants (n= 20)*

Measure	Angry Bias 500ms	Angry Bias 1250ms	Happy Bias 500ms	Happy Bias 1250ms	Sad Bias 500ms	Sad Bias 1250ms
ASI	.199	.005	.492	.303	.103	.006
STAI state	-.193	-.346	.676*	.303	.055	.092
STAI trait	-.249	-.398	.449	.354	.310	.230
TAS-20 total	.104	.005	.244	.133	.200	.284
TAS-20 - DIE	-.139	-.084	.323	.268	.046	.326
TAS-20 - DDE	.215	.031	.179	.183	.223	.383
HADS anxiety	-.041	-.104	.410	.384	.215	.122
HADS depression	-.187	-.118	.508	.484	.217	.141
CPAQ Total	.197	-.262	-.307	.155	.093	-.121
CPAQ willingness	.196	-.344	-.279	-.314	.212	-.154
CPAQ activities	.163	-.116	-.286	.064	-.067	-.061
Dividing attention CSQ	-.249	.326	-.074	.107	-.036	.168
Reinterpretation CSQ	-.144	-.040	.076	-.039	.278	.014
Catastrophising CSQ	-.453	-.010	.289	.230	.125	.273
Ignoring CSQ	-.013	-.161	-.048	.090	-.061	.215
Praying CSQ	-.295	.135	.154	.341	.308	.320
Coping CSQ	.044	-.130	-.135	.214	.175	.220
IBA CSQ	-.141	.136	.324	-.368	-.311	.149
Control CSQ	.152	.082	-.106	.037	-.069	-.144
Decrease CSQ	-.113	.038	-.216	.334	-.121	-.193
MPQ-SF	-.242	-.052	-.013	.054	.065	.399
Sensory MPQ-SF	-.494	-.251	.402	-.057	-.024	.179
Affective MPQ-SF total	-.358	-.132	.144	.016	.037	.349
(sensory + affective)						
MPQ-SF current pain	-.468	.119	.339	.162	-.086	.348
MPQ-SF overall pain	-.277	-.285	.019	.086	.340	.339
PSEQ	.142	-.041	-.156	-.122	-.119	-.271
Headache chronicity (in months)	.081	.047	.075	-.143	.060	-.204

\* Correlation is significant at the 0.01 level.

Table C.3

*Correlations between self-report measures and attentional bias scores for healthy control participants (n= 26)*

Measure	Angry Bias 500ms	Angry Bias 1250ms	Happy Bias 500ms	Happy Bias 1250ms	Sad Bias 500ms	Sad Bias 1250ms
ASI	.368	.132	-.113	.154	-.052	-.132
STAI state	.109	.442	-.111	.031	.014	-.114
STAI trait	.345	.380	-.160	.031	-.084	-.003
TAS-20 total	.268	.106	.113	.106	-.092	-.296
TAS-20 - DIE	.223	.193	.086	.122	-.241	-.272
TAS-20 - DDE	.263	.054	.055	.128	.045	-.270
HADS anxiety	-.225	.281	-.113	.189	.091	-.173
HADS depression	.091	.290	.034	.196	-.168	.055

\* Correlation is significant at the 0.01 level.

Table C.4

*Correlations between self-report measures and attentional bias scores for all chronic headache and control participants combined (N= 46)*

Measure	Angry Bias 500ms	Angry Bias 1250ms	Happy Bias 500ms	Happy Bias 1250ms	Sad Bias 500ms	Sad Bias 1250ms
ASI	.257	.074	.206	.145	-.061	-.091
STAI state	-.046	-.011	.407*	.105	-.022	-.012
STAI trait	.069	-.015	.206	.109	.062	.089
TAS-20 total	.187	.064	.172	.079	-.016	-.068
TAS-20 - DIE	.058	.065	.205	.113	-.172	-.022
TAS-20 - DDE	.232	.045	.117	.128	.099	-.002
HADS anxiety	-.152	.077	.200	.188	.060	-.045
HADS depression	-.065	.062	.275	.164	-.102	.037

\* Correlation is significant at the 0.01 level.

### Appendix D – Experiment 3

Table D.1

*Internal consistency for the self-report measures and subscales used in the current experiment.*

Measure	Cronbach's Alpha
ASI	.904
MBSS Acceptance	.690
MBSS Blunting	.517
STAI state	.907
STAI trait	.925
TAS-20 total	.846
TAS-20 - DIE	.842
TAS-20 - DDE	.754
TAS-20 – EOT	.526
HADS anxiety	.753
HADS depression	.753
RRQ Rumination	.925
RRQ Reflection	.915
CPAQ Willingness	.869
CPAQ Activities	.812
Dividing Attention CSQ	.793
Reinterpretation CSQ	.848
Catastrophising CSQ	.769
Ignoring CSQ	.861
Praying CSQ	.541
Coping self statements CSQ	.821
IBA CSQ	.755
MPQ-SF Sensory	.790
MPQ-SF Affective	.561
MPQ-SF Total (sensory + affective)	.834
PSEQ	.914
PVAQ	.798

Table D.2

*Correlations between self-report measures, pain duration and attentional bias scores for chronic headache participants (n= 37)*

Measure	Headache Bias 500ms	Headache Bias 1250ms	Pain Bias 500ms	Pain Bias 1250ms	Health Bias 500ms	Health Bias 1250ms	General Bias 500ms	General Bias 1250ms
ASI	-.218	-.123	.259	.244	.184	-.272	.123	-.070
STAI state	-.008	-.096	.396	.215	.240	.024	-.064	-.032
STAI trait	.076	.129	.260	.154	.135	.066	.065	.116
TAS-20 total	-.231	-.049	.239	.040	.109	-.007	.083	-.268
TAS-20 - DIE	-.150	-.111	.208	.087	.251	.041	.118	-.172
TAS-20 - DDE	-.095	.041	.339	.126	.161	.055	.138	-.302
HADS anxiety	-.033	-.220	.287	.214	.191	-.251	.175	-.283
HADS depression	.238	.016	.388	.068	.060	-.250	.167	.016
RRQ Rumination	.147	.031	.164	-.006	.161	.181	.056	.112
RRQ Reflection	.101	-.049	.099	-.117	.306	-.070	.132	-.071
CPAQ Willingness	.161	-.199	-.155	-.227	.040	-.201	.039	-.067
CPAQ Activities	-.025	.030	-.241	.007	.192	.155	.101	-.018
Dividing Attention CSQ	-.107	-.119	.262	.199	.143	-.003	-.149	-.010
Reinterpretation CSQ	.066	.011	.141	.196	-.138	-.193	-.215	-.342
Catastrophising CSQ	.172	-.095	.391	.066	-.013	.031	.047	.088
Ignoring CSQ	-.069	.020	.125	.124	.308	.054	-.093	-.127
Coping self statements CSQ	-.017	-.093	.042	.057	.239	-.075	.063	-.334
IBA CSQ	-.127	-.175	-.059	-.066	.241	-.025	-.096	-.109
Control CSQ	-.160	.080	-.301	-.012	-.338	-.152	-.113	-.077
Decrease CSQ	-.144	.089	-.214	.141	.062	.100	.069	-.248
MPQ-SF Sensory	.079	.237	.281	.205	-.006	.307	-.079	.138
MPQ-SF Affective	.156	.301	.348	.283	.083	.288	-.043	.231
MPQ-SF Total (sensory + affective)	.101	.236	.305	.237	.006	.310	-.089	.174
MPQ-SF Present pain	.041	-.155	.130	.043	.271	.369	.121	-.007
MPQ-SF Overall	-.056	.097	.184	.171	-.071	.079	-.180	.066
PSEQ	-.029	-.228	-.284	-.001	.140	-.031	-.129	-.093
PVAQ	.114	-.129	.053	-.018	.027	.079	.191	.051
CH chronicity	.030	.141	-.210	.082	-.062	-.022	.128	-.225

\* Correlation is significant at the 0.01 level.

Table D.3

*Correlations between self-report measures and attentional bias scores for healthy control participants (n= 38)*

Measure	Headache Bias 500ms	Headache Bias 1250ms	Pain Bias 500ms	Pain Bias 1250ms	Health Bias 500ms	Health Bias 1250ms	General Bias 500ms	General Bias 1250ms
ASI	-.044	.055	.221	-.035	-.136	.313	.112	.280
STAI state	.119	.094	.441*	.003	.132	-.139	.227	.415*
STAI trait	.069	.120	.310	.045	.225	.119	.294	.358
TAS-20 total	-.203	.082	.100	-.057	.183	.123	.103	.305
TAS-20 – DIE	-.202	-.005	.191	-.101	.189	.064	.209	.348
TAS-20 – DDE	-.065	.123	-.021	.119	.093	.226	.175	.301
HADS anxiety	.197	.029	.317	-.098	.125	-.014	.174	.043
HADS depression	-.250	-.235	.032	-.082	-.026	.125	.067	.237
RRQ Rumination	-.073	.138	.293	.103	.013	.230	.434*	.308
RRQ Reflection	.051	-.111	-.043	-.009	-.103	-.030	.201	.172

\* Correlation is significant at the 0.01 level.

Table D.4

*Correlations between self-report measures and attentional bias scores for all chronic headache and control participants combined (n= 75)*

Measure	Headache Bias 500ms	Headache Bias 1250ms	Pain Bias 500ms	Pain Bias 1250ms	Health Bias 500ms	Health Bias 1250ms	General Bias 500ms	General Bias 1250ms
ASI	-.126	.024	.262	.086	-.009	-.036	.069	.088
STAI state	.052	.026	.423*	.095	.165	-.062	.076	.183
STAI trait	.094	.189	.305*	.072	.141	.063	.124	.221
TAS-20 total	-.166	.126	.214	-.049	.084	.009	.006	-.006
TAS-20 - DIE	-.122	.051	.235	-.036	.155	.012	.071	.043
TAS-20 - DDE	-.064	.126	.200	.099	.099	.049	.112	-.041
HADS anxiety	.055	-.056	.313*	.068	.125	-.183	.118	-.158
HADS depression	.124	.076	.286	-.044	-.042	-.148	.010	.096
RRQ Rumination	.071	.093	.227	.036	.076	.194	.225	.198
RRQ Reflection	.042	-.172	-.017	-.021	-.009	-.036	.069	.088

\* Correlation is significant at the 0.01 level.

## Appendix E – Experiment 4

Table E.1.

*Internal consistency for the self-report measures and subscales used in the current investigation*

Measure	Cronbach's Alpha
ASI	.879
HDI total	.888
HDI emotional	.819
HDI functional	.807
MBSS Monitoring	.751
MBSS Blunting	.530
STAI state	.902
STAI trait	.916
TAS-20 total	.816
TAS-20 - DIE	.836
TAS-20 - DDE	.759
TAS-20 – EOT	.545
HADS anxiety	.656
HADS depression	.752
RRQ Rumination	.942
RRQ Reflection	.911
CPAQ Willingness	.829
CPAQ Activities	.820
Dividing Attention CSQ	.825
Reinterpretation CSQ	.850
Catastrophising CSQ	.825
Ignoring CSQ	.845
Praying CSQ	.657
Coping CSQ	.825
IBA CSQ	.703
MPQ-SF Sensory	.759
MPQ-SF Affective	.510
MPQ-SF Total (sensory + affective)	.790
PSEQ	.915
PVAQ	.842

Table E.2.

*Correlations between self-report measures, pain duration and interference scores for chronic headache participants (n= 32)*

Measure	Pain score	Angry score	Sad score	Fear score	Happy score
ASI	.063	-.135	.121	.163	.087
MBSS sum	.016	.271	.146	.010	.124
STAI state	.198	.293	.282	.273	.505*
STAI trait	.351	.391	.281	.062	.403
TAS-20 total	.285	.212	.355	.354	.343
TAS-20 - DIE	.342	.204	.233	.141	.208
TAS-20 - DDE	.291	.357	.402	.421	.321
HADS depression	.218	.265	.346	.231	.269
RRQ Ruminatation	.161	.361	.162	-.115	.182
RRQ Reflection	.070	.037	.120	-.088	.082
CPAQ Willingness	.012	.045	-.162	-.078	-.304
CPAQ Activities	-.111	-.362	-.278	-.248	-.416
Dividing Attention CSQ	.078	.142	.131	.056	.145
Reinterpretation CSQ	-.013	-.121	-.165	-.172	-.187
Catastrophising CSQ	.222	.401	.406	.140	.499*
Ignoring CSQ	.062	.113	-.034	.025	-.097
Coping CSQ	.250	.136	.124	.315	.131
IBA CSQ	.292	.252	.310	.277	.194
Control CSQ	-.388	-.233	-.206	-.243	-.315
Decrease CSQ	-.255	-.311	-.120	-.021	-.041
HDI-E	.374	.497*	.500*	.383	.481*
HDI-F	.202	.353	.485*	.445	.416
HDI Total	.311	.458*	.516*	.445	.483*
MPQ-SF Sensory	.288	.068	.283	.141	.093
MPQ-SF Total (sensory + affective)	.192	.031	.262	.111	.123
MPQ-SF Present pain	.392	.087	-.017	-.090	-.018
MPQ-SF Overall	.309	.087	.140	.210	.337
PSEQ	-.054	-.162	-.281	-.150	-.189
PVAQ	-.119	-.051	-.101	-.295	-.491*
CH duration (in months)	-.012	-.289	-.284	.020	-.175
COWA score	-.414	-.007	-.195	-.230	-.514*
CTMT score	-.313	.087	-.171	-.129	-.122

\*Correlation is significant at the 0.01 level.

Table E.3.

*Correlations between self-report measures and attentional bias scores for all healthy control participants (n= 35)*

Measure	Pain score	Angry score	Sad score	Fear score	Happy score
ASI	.137	.092	.137	-.031	.049
MBSS sum	-.312	-.004	-.016	-.166	-.116
STAI state	.177	.220	.087	.249	.112
STAI trait	.311	.221	.373	.365	.193
TAS-20 total	-.047	-.040	.069	-.045	-.215
TAS-20 - DIE	.066	.001	.147	.126	-.169
TAS-20 - DDE	.063	.099	.142	.027	-.092
HADS depression	-.130	-.160	-.232	-.207	-.168
RRQ Rumination	.104	.142	.349	.303	.035
RRQ Reflection	.061	.272	.090	.237	.120
COWA score	-.159	.109	-.202	-.031	-.290
CTMT score	.150	-.076	-.013	-.110	-.047

\*Correlation is significant at the 0.01 level.

Table E.4.

*Correlations between self-report measures and attentional bias scores for all chronic headache and control participants combined (n= 67)*

Measure	Pain score	Angry score	Sad score	Fear score	Happy score
ASI	.103	-.019	.174	.093	.112
MBSS sum	-.135	.145	.056	-.066	.017
STAI state	.184	.251	.142	.249	.266
STAI trait	.322*	.297	.356*	.224	.332*
TAS-20 total	.095	.069	.227	.169	.096
TAS-20 - DIE	.188	.092	.240	.170	.088
TAS-20 - DDE	.160	.216	.222	.204	.087
HADS depression	.061	.072	.171	.112	.183
RRQ Rumination	.130	.247	.282	.100	.135
RRQ Reflection	.062	.166	.058	.059	.062
COWA Score	-.279	.050	-.186	-.106	-.400
CTMT Score	-.065	.004	-.090	-.125	-.094

\* Correlation is significant at the 0.01 level.

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