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Using eye movements to investigate selective attention in chronic daily headache

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ABSTRACT

Previous research has demonstrated that chronic pain is associated with biased processing of pain-related information. Most studies have examined this bias by measuring response latencies. The present study extended previous work by recording eye movement behaviour in individuals with chronic headache and in healthy controls while participants viewed a set of images (ie, facial expressions) from 4 emotion categories (pain, angry, happy, neutral). Biases in initial orienting were assessed from the location of the initial shift in gaze, and biases in the maintenance of attention were assessed from the duration of gaze on the picture that was initially fixated, and the mean number of visits, and mean fixation duration per image category. The eye movement behaviour of the participants in the chronic headache group was characterised by a bias in initial shift of orienting to pain. There was no evidence of individuals with chronic headache visiting more often, or spending significantly more time viewing, pain images compared to other images. Both participant groups showed a significantly greater bias to maintain gaze longer on happy images, relative to pain, angry, and neutral images. Results are consistent with a pain-related bias that operates in the orienting of attention on pain-related stimuli, and suggest that chronic pain participants' attentional biases for pain-related information are evident even when other emotional stimuli are present. Pain-related information-processing biases appear to be a robust feature of chronic pain and may have an important role in the maintenance of the disorder.

1. Introduction

Attentional biases toward pain-related stimuli have been proposed in theories of attention and pain [31,52] and emotional processing [4,9,54], and have been empirically demonstrated in patients with musculoskeletal pain [18,22] and chronic headache [25,26,38,39]. Recent meta-analyses [12,40] have confirmed that individuals with chronic pain, when compared to healthy controls, demonstrated significantly greater bias towards pain-related information at stimuli presentation times $\leqslant$500 ms and $\geqslant$1000 ms. Research into bias specificity has shown that attentional biases in chronic pain are specific towards pain-related information only, with no significant differences between chronic pain and healthy control groups found in bias for non–pain-related threat (ie, anger-related, social threat [26]; social threat, movement [35]; and health threat, general threat [39]).

Attentional biases may stem from different underlying processes, including facilitated orienting towards threat (ie, faster detection of threat), difficulties disengaging from threat (ie, slower to shift attention away from threat) or avoidance of threat (ie, attention is allocated away from threat) [8]. Specific difficulties disengaging from pain-related stimuli have been reported [2,34,42], but the distinction between facilitated orientation and difficulty disengaging is complex and warrants further investigation. In addition, the effects described above were derived from the visual probe task (although other paradigms have been used [7,50,51]), an extensively used paradigm that nonetheless has limitations. The visual probe task captures only a brief snapshot of attentional processing for each stimulus exposure duration used [11,29]. Eye-tracking methodology offers certain advantages over this approach, providing an index of the pattern of fixations and saccades that are made as participants complete a task [12,14,23]. An additional constraint of the visual probe task is that during experimental trials, only 2 images are presented, 1 of which is always neutral. As a result, it is currently unknown whether attentional biases in chronic pain are shown when multiple emotionally salient images have been presented. To clarify previous research into the time course of biased attention in chronic pain, and

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to use a more direct method that taps into visual and attentional processes that occur during normal inspection of a visual stimulus, we used a paradigm similar to that of Eizenman et al. [15] and Kellough et al. [21]. The eye movement behaviour of participants was recorded as they freely inspected 4 concurrently presented images of different facial expressions (ie, pain, angry, happy, and neutral).

According to the theoretical views [4,9,31,54,56] and previous research [18,22,25,26,38,39] noted earlier, it was predicted that individuals with chronic headache, compared to healthy controls, would demonstrate biases in (i) *initial orienting of attention*, manifested as significantly higher proportion of initial fixations on pain expressions, coupled with a higher than chance probability of the initial fixation to be directed to a pain image; and (ii) *attentional engagement,* manifested as longer initial fixations and significantly more visits to pain expressions of significantly longer duration. The current investigation also explored the specificity of bias when negatively valenced, positively valenced, and neutral target pictures were presented simultaneously.

2. Methods

2.1. Participants

Participants were recruited via press announcements from the South of England. Inclusion criteria for the chronic daily headache (CDH) group were as follows: (a) having been diagnosed with primary tension-type headache or migraine by a general practitioner or consultant neurologist, and satisfying the criteria stated in the International Classification of Headache Disorders 2nd edition [44] (ie, occurring 15 or more days per month, for more than 3 months and in the absence of medication overuse); (b) age 18 years or more; and (c) normal or corrected-to-normal vision. Exclusion criteria were the following: (a) having a diagnosis or receiving treatment for any psychiatric disorder, either currently or within the past 5 years; and (b) experiencing any other form of chronic pain, including secondary headache (ie, caused by another medical disorder). Inclusion criteria for the healthy control group were (a) age 18 years or more, and (b) normal or corrected-to-normal vision. Exclusion criteria were (a) having been diagnosed with a psychiatric disorder within the past 5 years, (b) experiencing any form of chronic or recurrent pain (in terms of headache frequency having more than 7 headaches per month); and (c) taking any psychotropic or analgesic medication regularly. Based on these criteria, 2 individuals were excluded who did not meet criteria for chronic headache, and 2 individuals with impaired vision. All individuals with migraines were booked to complete the experiment during the interictal period (ie, when they were not experiencing a migraine attack). There were difficulties calibrating the eye-tracker for 6 participants, who were therefore excluded from the investigation and not considered further. Data from 46 participants (mean age = 45.61 years, SD = 14.93 years) was available for analysis, including 23 participants with chronic headache (mean age = 47.43 years, SD = 14.12 years; range = 18–69 years) and 23 pain-free, healthy control participants (mean age, 43.78 years; SD = 15.80 years; range = 21–64 years). Twenty-six participants (57%) were female. Chronic headache participants reported living with headache for a mean duration of 18.8 years (SD = 11.11 years, range = 4–40 years), with the majority ($n = 16$; 70%) experiencing 1 headache per day. Fifteen participants (65%) had tension-type headache, and 8 (35%) migraine. Eleven (48%) reported at least 1 relative also to experience regular headache. As indexed by their Migraine Disability Assessment Scores (MIDAS), 10 (43%) participants indicated severe disability as a consequence of their headaches. All but 3 (87%) in response to their headaches were taking medication regularly, with 13 (57%) reporting the use of prescription medication, and 26 (61%) the use of over-the-counter medication.

2.2. Questionnaire measures

The following questionnaires were used to characterise the sample and to assess cognitive and emotional aspects of participants' pain experience.

The State-Trait Anxiety Inventory (STAI) [45] is a 40-item self-report measure of state and trait anxiety. Possible scores for both state and trait levels range between 20 and 80, with higher scores representing more intense or more frequent feelings of anxiety. Barnes et al [3] explored reliability generalisation in 816 research articles using the STAI between 1990 and 2000. Reliability coefficients showed an internal consistency of 0.91 and 0.89 for the state and trait scales respectively. Test–retest reliability was 0.70 and 0.88 respectively. Cronbach's α in the current investigation for the state and trait subscales were 0.90 and 0.92, respectively.

The Hospital Anxiety and Depression Scale (HADS) [59] is a self-report questionnaire that rates the severity of 7 symptoms of anxiety and 7 symptoms of depression over the previous week. Scores are constructed by summation, whereby increasing scores indicate increasing burden, and yielding a total score, an anxiety score, and a depression score. The HADS was designed for use in persons with physical illness, as it omits the bodily symptoms of depression that may be caused by physical illness. The HADS has been well validated by research studies, with a large-scale investigation ($n = 51{,}936$) revealing an internal consistency of 0.80 and 0.76 for anxiety and depression subscales, respectively [30]. Cronbach's α in the current investigation for the anxiety and depression subscales were 0.80 and 0.79, respectively.

The Migraine Disability Assessment Questionnaire (MIDAS) [49] assesses headache-related disability. Individuals with headache answer 5 questions, scoring the number of days, in the past 3 months, of activity limitations because of headache. The overall score is categorized to yield 4 grades of increasing disability. The MIDAS has been shown to be internally consistent, highly reliable, and valid, and to correlate with physicians' clinical judgment [47,48]. In line with current clinical practice and research, the MIDAS was used for all participants with chronic headache, regardless of type [19,27]. Cronbach's α in the current investigation was 0.23. (This low value can be attributed to the fact that some participants were retired, and therefore answered "0" for questions regarding to how many work days were affected by headache. This led to a low intercorrelation among the items.)

The short-form McGill Pain Questionnaire (MPQ-SF) [28,57] consists of a 15-item adjective checklist designed to assess affective and sensory aspects of pain, as well as 2 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 0.78 and 0.76 respectively) [57]. Research has also supported the high reliability of the self-administered MPQ-SF (intraclass correlation coefficients for the subscales: total = 0.96, sensory = 0.89, affective = 0.89, and average pain = 0.88) [17]. Cronbach's α in the current investigation for total, sensory, and affective descriptors were 0.72, 0.57, and 0.81, respectively.

2.3. Apparatus and visual-scanning task

Stimuli were presented on a 21-inch P227f Viewsonic monitor, with a 1024×768-pixel resolution and a 100-Hz refresh rate. Eye-movement data were recorded via an SR-Research Eyelink 1000 eye tracker system, running at 1000 Hz. The experiment was programmed and run with SR-Research Experiment Builder. For the detection of fixations and saccades, the recommended settings