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The effect of threat on attentional interruption by pain

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ABSTRACT

Pain is known to interrupt attention. This interruption is highly sensitive to the extent of involvement of both attentional control and the level of threat associated with the sensation. However, few studies have examined these factors together. This study aimed to examine the interruptive effect of pain on higher-order attentional tasks under conditions of low and high threat. Fifty participants completed an n-back task, an attentional switching task, and a divided attention task, once in pain and once without pain. Twenty-five participants were given standard task instructions (control condition), and the remainder were given additional verbal information designed to increase threat (threat condition). Pain interrupted participant performance on both the n-back and attentional switching task, but not on the divided attention task. The addition of the threat manipulation did not seem to significantly alter the effect of pain on these attentional tasks. However, independent of pain, threat did moderate performance on the divided attention task. These findings support the robustness of the effect of pain on performance on higher-order attention tasks. Future research is needed to examine what factors alter the cognitive interruption caused by pain.

1. Introduction

There is a growing consensus surrounding the importance of attentional processes in pain [6,15]. Pain functions to warn of potential danger and promote analgesic behaviour in oneself and from others. A reason for this interference effect is because attention has limits [11,17,26]. When competing demands are presented preferential selection occurs, and this is usually towards pain [33].

Although studies demonstrate that task performance deteriorates under painful conditions [4,7,8], such effects are not always found, and can depend on task-related factors [2,35]. For example, when measuring attention span, Bingel et al. [2] found an effect of laser-induced pain on a more complex 2-back task, but not the 1-back task. To help explain this discrepancy, Legrain et al. [15] suggest that there is a range of influences, including top-down motivational characteristics (eg, avoidance of harm and threat value) as well as bottom-up characteristics of the stimulus (eg, intensity and novelty). Bottom-up factors are proposed to alert a person to the salience of pain and top-down factors to control pain. The question now turns to identifying under which conditions pain interference is more likely to occur.

One line of research has been to investigate whether there are certain tasks that are more or less susceptible to pain-related interference. Moore et al. [25] found that heat-induced pain affected performance on complex tasks such as divided attention, switching and attention span, but not on simpler tasks such as those involving continuous performance. One explanation is that these more complex tasks reflect a general attentional deficit. An alternative explanation is that tasks that require more complex, executive-like demand have the greatest interruption effect from pain. Indeed, Miyake et al. [22] suggested that executive function is made up of shifting/switching (eg, switching task), inhibition, and updating (eg, n-back task). These are exactly the higher-order cognitive functions implicated in attention to pain [8,14].

Although higher-order executive-like tasks seem to be vulnerable to pain interference effects, it is likely that other contextual factors may increase or decrease this vulnerability. For example, if a person finds themselves in a threatening situation then the presence of threat can increase susceptibility to pain interference [5,14,30,31]. The threat of pain differs from the sensation of pain by adding psychological distress to nociception and can operate in the anticipation of pain as well as the presence of it. It is possible, therefore, that pain-related interference of executive-type tasks may be particularly pronounced under conditions of high threat. The aim of the current study was to examine whether situational threat moderates pain-related interference on executive-like cognitive tasks. We sought to address this question by using similar cognitively demanding tasks to those used previously [25], and combining them with an experimental manipulation of

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mild pain-related threat used in previous studies [14,33]. We hypothesised that pain will have a significant interference effect on these tasks, and threat will increase this interference effect.

2. Methods

2.1. Design

In a mixed-groups design, participants were assigned randomly to either a threat condition or a control condition. After randomisation, all participants completed 3 cognitive tasks on 2 occasions: once while experiencing a mild painful sensation, and once without a pain sensation (control). The dependent variables were performance indicators (eg, reaction time, accuracy) derived from the 3 tasks.

2.2. Participants

Fifty adult participants (21 men) were recruited into the study from the University of Bath staff and student population. Their mean age was 22.06 (SD 5.35) years. Participants reported that they were not currently in pain, had no existing chronic pain condition, and were not taking analgesic medication. Participants also reported no skin complaints or sensitivity, and all were paid a modest sum for participation.

2.3. Attention tasks

Three tasks were used in the current study, all of which were drawn from those used in a previous study [25]. The tasks were designed and controlled by E-Prime II professional software [29]. Stimuli were presented on a Iiyama prolite B1902S TFT monitor, which was powered by a Viglen genie desktop computer with a 3 GHz Pentium Intel Core 2 duo processor and 2 Gb of RAM. Responses were made with a PST model 200a serial response box. The 3 tasks were as follows.

2.3.1. Attention span task

Attention span is the amount of information that can be processed at any one time [16]. The n-back task was used, as it measures attention span by asking participants to indicate whether a current stimulus matches one presented previously. Participants were presented with a stream of 90 letters, each for 500 ms, followed by a 1500-ms blank screen. The participants' task was to report whether the current letter matched the letter presented 2 letters previously. Participants pressed one key if the letter was the same and another if the letter was different. There were 30 target stimuli presented and 60 nontarget stimuli randomly distributed through the task, and the task lasted approximately 3 min. The outcome variables for the n-back task were the number of correctly identified targets (hits), number of missed targets (misses), number of times nontargets were identified as targets (false alarms), and the number of nontargets correctly identified (correct rejections). In the current study, the n-back task was considered to be a measure of attention span related to executive functioning [3,18]. Although the n-back task is also used as a measure of working memory (eg, [10,12]) and may involve some of these components, the correlation between the n-back task and other working memory measures has been demonstrated to be low (eg, [9,13]).

2.3.2. Attentional switching task

Attentional switching is the process of alternating between multiple separate attentional tasks. Responses after task switches are typically slower and less accurate than task repetitions. These switch costs reflect an aspect of executive control processing, with some suggesting that task-switch costs in response time reflect the duration of an executive control process [20,23,28]. The present switching task is based on that of a previous study [1] in which a simple single digit is presented to participants who have to classify this as higher or lower than 5 or odd/even depending on secondary cues. This was conducted using a task-cueing paradigm [20] in which participants are cued to which task to perform on each trial. The task-cueing approach was developed as an alternative to predict sequence task switching (eg, AABBAABB). There is some evidence that the use of random trial orders as in the task-cueing paradigm can result in greater switch costs than the use of predictable runs [24].

In the current task, participants were presented with single-digit numbers (1, 2, 3, 4, 6, 7, 8, 9) which occupied 0.7° of visual angle on the screen. On some trials participants indicated whether the number was odd or even, whereas on other trials they indicated whether the number was greater or less than 5. A response box was used to collect responses, which consisted of 5 buttons, numerically labelled 1 through 5. Participants were asked to press the '1' key on the response box if the number was odd and the '5' key if the number was even. In the high vs low task, they pressed the '1' key if the number was less than 5 and the '5' key if the number was greater than 5. For each trial, the task could either remain the same as the one just completed or randomly switch to the alternative task. A priming screen was presented for 500 ms before the presentation of the numbers, which indicated how participants should respond (odd/even or high/low). Target stimuli were presented to participants until response. A total of 200 trials were presented, with a total duration of approximately 6 min. The outcome variables for this task were reaction time and accuracy.

2.3.3. Divided attention task

Divided attention is the ability to process more than one source of information simultaneously [38]. The divided attention task used in the current experiment was based on one previously used in a study of the effects of alcohol on divided attention [21,25]. Participants were presented with a display consisting of a central number and 2 lines which could be either horizontal or vertical in orientation. They were then presented with 400 displays, each display being presented for 1 s. The central number occupied 0.7° of visual angle, and the lines were presented 14.2° from the centre. For the numbers task, participants responded with a single key press when 3 consecutive odd or even digits were presented. The other task involved responding with the same key used for the numbers task when the 2 lines were presented in different orientations. Participants were asked to respond with the same response when either a number target was presented or when a line target was presented. There were 8 numbers and 8 lines targets per 80 displays, and numbers and lines target were never both presented on the same trial. The task lasted approximately 7 min. The outcome variable was accuracy.

2.4. Pain manipulation

Pain stimulation was achieved through the use of a Medoc PATHWAY—Advanced Thermal Stimulator (ATS). This has been designed for use in clinical and research settings, and induces pain through a metal plate, which is placed on the skin. The temperature of the plate increases or decreases; it is delivered and controlled through specialised hardware and software, designed for experimental purposes.

Individual pain thresholds were generated using a search protocol. A 30 × 30 mm thermode was attached to the participant's right ankle. The thermode started from a baseline temperature of 32°C, and participants altered the temperature using 2 buttons, one to