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Attentional bias modification and pain: The role of sensory and affective stimuli

Jemma Todd*, Louise Sharpe, Ben Colagiuri

School of Psychology, University of Sydney, Sydney, NSW 2006, Australia

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ABSTRACT

There is growing evidence to support attentional bias modification (ABM) techniques such as the modified dot-probe task within the pain literature. Such techniques can help to inform theoretical models of pain by identifying the causal role of attentional bias constructs. The aim of this research was to explore the effects of dot-probe ABM that trains individuals towards (+) or away from (−) sensory (S) and affective (A) pain words, on attentional biases, interpretation biases, and pain outcomes. Healthy undergraduate students (N = 106) completed questionnaires, an attentional bias dot-probe task, and an interpretation bias task before and after ABM, one of four ABM versions that differed in training direction (S+A+, S-A+, S+A-, S-A-), and pain outcomes using the cold pressor task. Those trained towards affective pain words were found to have a greater pain threshold but also greater distress at tolerance. However, mechanisms of change could not be established, as ABM did not affect attentional or interpretation bias, even though changes in attentional bias were associated with pain outcomes. These findings provide partial support for the threat interpretation model and highlight the utility of affective pain ABM, although further investigation of causal mechanisms is warranted.

1. Introduction

Research exploring the role of attentional biases in the experience of pain is growing rapidly, with a number of recent systematic reviews (Pincus & Morley, 2001; Todd et al., 2015) and meta-analyses (Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013; Schoth, Nunes, & Liossi, 2012) having been published. Importantly, although most researchers agree that attentional biases play a role in pain, the specific nature of these attentional biases is still yet to be determined and research to date remains somewhat inconsistent regarding the best parameters under which to detect these biases. For example, in Crombez et al.'s (2013) meta-analysis of cross-sectional studies, the strongest attentional biases were observed for sensory pain stimuli (e.g. shooting, burning), with biases towards sensory pain words being present in chronic pain patients in comparison with healthy participants. They did not however find any relationship between attentional biases and pain outcomes. Conversely, we recently reviewed prospective studies and found that avoidance of salient stimuli or a bias towards positive stimuli predicted chronicity (Todd et al., 2015).

A number of models have implicated cognitive processing biases such as attentional bias in the development and maintenance of chronic pain. For example, within the fear of (re)injury model (Vlaeyen & Linton, 2000) and subsequent fear-avoidance model (Crombez, Eccleston, Van Damme, Vlaeyen, & Karoly, 2012), it is proposed that chronic pain is maintained through a process of catastrophic pain interpretation and pain-related fear, which leads to attentional hypervigilance in an attempt to avoid further pain, which in turn contributes to increased depression and disability.

The role of attentional bias in pain has also been investigated using attentional bias modification (ABM) procedures, which is often based on a modified dot-probe task (MacLeod, Mathews, & Tata, 1986). Dot-probe ABM, in the context of pain research, involves training individuals to pay attention towards or away from pain-related information, and as such is designed to specifically reduce pain by influencing attentional processes that are thought to underlie how pain-related information is processed. To date there has been some success in using ABM to improve pain outcomes or associated disability in both chronic and acute pain samples (Sharpe et al., 2012) and in laboratory research (McGowan, Sharpe, Refshauge, & Nicholas, 2009; Sharpe, Johnson, & Dear, 2015). Our recent review of prospective pain literature suggested that whilst

* Corresponding author.
E-mail address: jemma.todd@sydney.edu.au (J. Todd).

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ABM is promising and generally leads to improvement on at least one primary pain outcome, the mechanisms of this improvement are less clear (Todd et al., 2015). However, despite improvements in pain outcomes, ABM training does not consistently bring about changes in attentional biases, the assumed mechanism, particularly in clinical samples (Todd et al., 2015).

ABM procedures training *away from* pain-related information have tended to result in improvements in pain outcomes in comparison with training towards pain-related information (McGowan et al., 2009; Sharpe et al., 2015). These ABM procedures have been developed from the predictive research in which individuals with chronic pain tend to exhibit a bias *towards* sensory pain information that is not present in healthy participants (Crombez et al., 2013). However, some research has found an opposite pattern; particularly for affective pain stimuli. For example, although acute pain patients exhibit the same biases towards sensory pain words that have been identified in chronic pain patients, these biases do not predict subsequent pain. Rather, biases *away from* affective pain stimuli (e.g. unbearable, vicious) have been found to predict the development of chronicity in acute pain patients (Sharpe, 2014). If one were to rely on the prospective literature to develop ABM protocols, it would be expected that ABM procedures training *towards* affective pain-related information would be more effective. Whilst training towards affective pain-related information has not been investigated for pain, training individuals towards threat stimuli has been applied to PTSD, where evidence that avoidance is a putative attentional process also exists. For example, Bar-Haim et al. (2010) found that amongst those exposed to real bomb threats, those who avoided threatening stimuli showed increased distress. Similar results were found by Wald et al. (2011), whereby those who avoided threatening stimuli during real threats of rocket attacks had increased risk of PTSD. Based on the existing ABM findings for threat, Wald et al. (In Press) developed an ABM protocol that trained Israeli soldiers to attend *towards* threatening stimuli. The results indicated that ABM training towards threat was associated with fewer PTSD symptoms following deployment in comparison to a placebo control group.

Whilst attentional biases towards threat and pain are not identical, it is important to note that the patterns of attentional avoidance of threat described in relation to PTSD appear to most closely match studies exploring attentional processes in relation to affective pain stimuli. That is, in pain there is evidence of a bias towards sensory pain words, but it appears that avoidance of affective pain is subsequently associated with poorer outcomes. Within the pain literature, it has tended to be sensory pain biases that have been modified with ABM (Schoth & Liossi, 2010; Sharpe et al., 2015) or a combination of sensory, affective, threat and disability words has been used with no ability to distinguish stimulus specific effects (McGowan et al., 2009; Sharpe et al., 2012). There is very little research comparing the effectiveness of training with different types of stimuli and comparing training towards and away from these stimuli. Therefore, we wanted to investigate the efficacy of training towards versus training away from both sensory and affective pain words in a laboratory pain paradigm.

Another complicating factor for ABM pain research is that attentional bias is a dynamic rather than a single static construct that is assessed using reaction time responses to the dot-probe paradigm (Crombez, Heathcote, & Fox, 2015). More recently, eye tracking measures have been successfully used to determine different attentional components that may be present (Priebe, Messingschlager, & Lautenbacher, 2015; Yang, Jackson, & Chen, 2013; Yang, Jackson, Gao, & Chen, 2012) and have been argued to be more accurate and reliable than traditional reaction time measures of attention (Cooper & Langton, 2006; Sharpe, 2014).

The time course of attentional biases has been further explored in the threat interpretation model (Todd et al., 2015), which was recently developed from the available prospective and experimental research. The threat interpretation model makes a number of predictions, including that as threat increases, attentional biases will be characterised by increased attentional vigilance at early stages of attentional processing. At later stages of attentional processing, it is proposed that there will be a pattern of effective disengagement with low threat, difficulty disengaging with moderate threat, or avoidance with high threat levels. Further, the threat interpretation model suggests that attentional biases are likely to depend on whether or not pain information is interpreted as threatening. Interpretation biases are defined as the interpretation of ambiguous information as being threatening (or painful) in the absence of sufficient contextual cues (Pincus & Morley, 2001). Therefore, according to the threat interpretation model it is expected that ABM procedures may have some effect on interpretation biases, as has been found in anxiety literature (White, Suway, Pine, Bar-Haim, & Fox, 2011), but is yet to be tested for pain. Cross-sectional research has found an association between pain-related attentional bias and questionnaire measures of interpretation bias (Keogh & Cochrane, 2002). There has also been one study that has investigated this relationship using a computer based reaction time measure of biased interpretation, however that study failed to find an association (Todd, Sharpe, Colagiuri, & Khatibi, In Press). To date, no study has manipulated attentional bias to determine the effects on interpretation bias.

The current research was designed to determine the effectiveness of different forms of ABM on attentional biases, interpretation biases, and pain outcomes. Given the limited amount of ABM interventions in the pain literature, the study was broadly-speaking exploratory. However, as it has generally been found that biases towards sensory pain words but away from affective pain words play some role in explaining pain outcomes, it would be expected that ABM training away from sensory and towards affective pain words would be the most effective in reducing attentional biases and improving pain outcomes. Further, we sought to explore which components of attentional bias change with ABM training, and whether these changes in attention mediate the effects of ABM on pain outcomes. In particular, the components of attention that we were interested in were early and later stages of processing, which were assessed using eye-tracking technology in addition to traditional reaction time measures.

2. Method

2.1. Participants and design

Participants were 106 first year university students. Inclusion criteria were: being over 18 years of age, being proficient in English, having no instances of prolonged pain in the 3 months prior to testing, and not currently experiencing acute pain (pain ratings of <4/10 on a numerical rating scale). Participation was voluntary and in exchange for course credit. A randomised controlled trial design was used, with both researchers and participants blind to group allocation. Participants were randomly allocated to one of the four training conditions (A+S+, A+S−, A−S+, A−S−; where A = affective pain stimuli, S = sensory pain stimuli, + = training towards pain stimuli, − = training away from pain stimuli; such that A+S− is training towards affective pain stimuli but away from sensory pain stimuli). Random allocation was achieved by firstly allocating participants to a unique random number via a list of computer-generated numbers (www.randomizer.org), which was then fed into the ABM program where participants were allocated to a group based on this number. Therefore, allocation to group did not occur until the ABM task was commenced and was concealed