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Increasing optimism abolishes pain-induced impairments in executive task performance

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ABSTRACT

Coping with the demands of pain diminishes self-regulatory capacity and causes self-regulatory fatigue, which then leads to deteriorated executive task performance. It has been suggested that optimism can counteract the depletion of self-regulatory capacity. This study employed a 2 (optimism/no optimism) × 2 (pain/no pain) between-subjects design to explore whether (1) experimentally induced pain (cold pressor task) deteriorates subsequent executive task performance, and (2) whether an optimism induction can counteract this sustained deteriorating effect of pain on executive task performance. Results indicated that although pain led to significantly worse performance on the executive functioning task in the no optimism condition, this sustained deteriorating effect of pain on task performance was abolished in the optimism condition. This finding is imperative because it suggests that optimism may be an important factor to implement in current psychological treatment approaches to diminish the negative impact of chronic pain on the ability to function in daily life.

1. Introduction

Pain interrupts, interferes, and deteriorates executive task performance because pain attracts an individual's attention [10,20,21,37]. Prior studies on the interruptive effect of pain have routinely adopted dual-task paradigms that present painful stimuli during executive tasks performance [10,36,37]. Although this approach is highly suitable for testing the effects of pain on attention, it does not allow for the examination of whether pain might have sustained deteriorating effects on task performance [55]. The experience of pain may fatigue self-regulation resources, leading to deterioration in executive task performance [54]. Self-regulation is the ability to control or alter thoughts, emotion, and behaviour [5,11]. Coping with the demands of pain requires self-regulation, but this capacity is limited [21,54,55]. Self-regulation ability, to some extent, depends on executive functioning capacity, the ability to actively monitor behaviour, thoughts, and memory [52]. Ironically, self-regulatory efforts reduce executive functioning ability [9,27,30,54], causing a downward spiral to ensue in which self-regulatory demands cause self-regulatory fatigue, reducing executive functioning capacity, making it more difficult to meet additional self-regulatory demands [10,55].

People differ in their executive functioning and self-regulatory capacity [7]. One important individual difference variable in this respect may be optimism [46,53,65]. Optimism reflects an individual's tendency to expect that good things will happen in the future [44]. Optimism has a substantial impact on an individual's ability to cope with adversity, as optimists are more inclined to display approach coping strategies that are aimed at eliminating or managing stressors [56,57]. When confronted with pain, optimists are more likely to continue investing effort to obtain their goals [1,13,19] and show better adaptation to pain [2,8]. These beneficial effects of optimism may be related to higher self-regulatory and executive functioning capacity, leading to higher goal perseverance and adaptation to the challenges of pain [46,65].

This study examines whether optimism abolishes the deteriorating effect of pain on executive task performance. In the present study, the executive functioning task occurred after the pain induction to allow testing the hypothesis that pain has sustained deteriorating effects on executive functioning, thereby reflecting self-regulatory fatigue. In order to demonstrate that optimism causally influences the impact of pain on executive task performance, we employed an optimism induction manipulation. This manipulation is able to induce a temporary optimistic state and has previously been found to diminish self-regulatory fatigue [34] and pain sensitivity [25].

In summary, in order to test the hypotheses that (1) experimentally induced pain will deteriorate subsequent executive task

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performance and (2) an optimism induction counteracts this sustained deteriorating effect of pain on executive task performance, we set up an experiment in which participants completed an executive functioning task after being subjected to either painful cold water or comfortably warm water. Moreover, half of the participants received an optimism manipulation prior to the painful or nonpainful water task.

2. Methods

2.1. Participants

A total of 80 healthy undergraduates from Maastricht University participated in the study. Exclusion criteria were suffering from a chronic pain disorder or currently experiencing pain, cardiovascular disease, or Reynaud disease. Six participants were excluded from the analysis because they were nonnative Dutch speakers. Although the inclusion criteria only stated that a good comprehension of Dutch language was required, remembering unrelated 1-syllable Dutch words may add a level of complexity to the executive functioning task (see measures) for nonnative Dutch speakers. The remaining 74 participants (16 male) had a mean age of 21.9 years (SD = 2.29). Participants were randomly assigned to 1 of the 4 conditions: (1) optimism and pain (n = 20, 5 male), (2) optimism and no pain (n = 18, 4 male), (3) no optimism and pain (n = 17, 3 male), and (4) no optimism and no pain (n = 19, 4 male). Participants were informed during the recruitment that there was a possibility that they would be assigned to a pain condition. Participants received a gift voucher of 10 euro for their participation. The local ethical committee of the Faculty of Psychology and Neuroscience, Maastricht University, approved the study protocol.

2.2. Manipulations

2.2.1. Optimism manipulation

Optimism was induced by the Best Possible Self (BPS) manipulation, a positive future thinking technique based on work by King [31]. BPS has been proven effective in increasing positive affect and positive future expectancies [25,40]. Participants were instructed to carry out a writing and imagery exercise. Half of the participants were assigned to the BPS condition (n = 38), which required them to write about a life in the future where everything turned out for the best. The other half of the participants were assigned to the control condition (n = 36), which consisted of writing about a Typical Day (TD). The instructions were as follows [40,51]: BPS condition, "'Think about your best possible self' means that you imagine yourself in the future, after everything has gone as well as it possibly could. You have worked hard and succeeded at accomplishing all the goals of your life. Think of this as the realization of your dreams, and that you have reached your full potential.'" TD condition, "'Think about your typical day' means that you take notice of ordinary details of your day that you usually don't think about. These might include particular classes or meetings you attend to, people you meet, things you do, typical thoughts you have during the day. Think of this as moving through your typical day, hour after hour."

Both manipulations had the same procedural format: participants were requested to think for 1 minute about what to write, then to write uninterrupted for 15 minutes, followed by 5 minutes of imaging the story they had just finished writing. Instructions were given both verbally and in writing.

2.2.2. Pain manipulation

In the pain condition (n = 37), the Cold Pressor Task (CPT) was used to induce a painful sensation. The water tank consisted of a Plexiglas box (JULABO Labortechnik GmbH, Seelbach, Germany) filled with water that was kept constant at 2°C using an electrical immersion cooler (JULABO type FT200) and a circulation pump (JULABO type ED-19). The immersion duration was set at a maximum of 3 minutes [14]. Participants were explicitly informed that the procedure could be painful and that they could stop the task at any point without consequences. The instructions before immersion were as follows: "The aim of the task is to submerge your right hand in this cold water tank for as long as possible until you cannot take it anymore. When you cannot take it any longer, you are allowed to remove your hand from the water. Try, however, to hold on as long as possible." Participants were not aware of the preset time limit. If the 3-minute maximum was achieved, the experimenter signalled the participant to remove the hand from the water.

Participants in the no pain condition (n = 37) followed the same procedure, with the exception that the water temperature was a comfortable 34°C (warm water control task [WWCT]). Furthermore, to match immersion times of the CPT, participants were randomly requested to remove their hand from the water at 1, 2, or 3 minutes after immersion [47].

2.3. Executive functioning

2.3.1. Operation-span task

The operation-span task [60] is a working memory task that requires active maintenance of stored information while concurrently processing another source of information. In the operation-span task, participants have to remember and recall unrelated words in their order of presentation while simultaneously solving arithmetic problems. Processing the arithmetic problems interferes with recruitment of strategies, such as rehearsal or grouping, to maintain the stored information (ie, the words). The operation-span task relies on executive functioning capacity to overcome this interference and to help maintain and recall the presented words [17,29]. For this reason, the operation-span task is thought to reflect executive functioning [23,28].

The task consists of 2 procedural aspects. First, participants read aloud a mathematical problem that consists of 2 arithmetic operations on 1 side of the equation and an offered solution on the other side of the equation. The first operation is a multiplication or division problem, the second operation contains an addition or subtraction problem (eg, is (6/2) + 5 = 8?). The equation is presented centrally on a computer screen. After reading the mathematical problem aloud, the participant verbally states whether the offered solution is correct or incorrect, which the experimenter registers on an answer form. Second, behind each equation a 1-syllable word is presented, which has to be remembered for later serial recall (eg, is (6/2) + 5 = 8? bread). The presented word is also read aloud by the participant. The presentation of the equation and word combination disappears from the screen when the participant presses the space key, introducing a 100-ms blank interval before the next equation and word combination appears. The presentation of equation and word combinations continues until a question mark is presented on the screen. This signals the participant to start to write down the words in that trial, in order of presentation, on an answer sheet. The participants are informed that they should report as many words as were presented, and it is emphasized that the order of the words is important and that they are allowed to guess. There is no time constraint on this recall task.

In total, the operation-span task comprises 12 trials, preceded by 1 practice trial. One trial can consist of 2, 3, 4, or 5 equation and word combinations, which are presented sequentially. Every possible trial length (eg, 2, 3, 4, or 5) is displayed 3 times. The presentation sequence of trials is randomized, which eliminates any strategy that is built on knowledge about the amount of words that