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Attention effects on vicarious modulation of nociception and pain

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ABSTRACT

The observation of others' facial expressions of pain has been shown to facilitate the observer's nociceptive responses and to increase pain perception. We investigated how this vicarious facilitation effect is modulated by directing the observer's attention toward the meaning of pain expression or the facial movements. In separate trials, participants were instructed to assess the "intensity of the pain expression"(meaning) or to "discriminate the facial movements" in the upper vs lower part of the face shown in 1-second dynamic clips displaying mild, moderate, or strong pain expressions or a neutral control. In 50% of the trials, participants received a painful electrical stimulation to the sural nerve immediately after the presentation of the expression. Low-level nociceptive reactivity was measured with the RIII-response, and pain perception was assessed using pain ratings. Pain induced by the electrical stimulation increased after viewing stronger pain expressions in both tasks, but the RIII-response showed this vicarious facilitation effect only in the movement discrimination task at the strongest expression intensity. These findings are consistent with the notion that vicarious processes facilitate self-pain and may prime automatic nociceptive responses. However, this priming effect is influenced by top-down attentional processes. These results provide another case of dissociation between reflexive and perceptual processes, consistent with the involvement of partly separate brain networks in the regulation of cortical and lower-level nociceptive responses. Combined with previous results, these findings suggest that vicarious pain facilitation is an automatic process that may be diminished by top-down attentional processes directed at the meaning of the expression.

1. Introduction

Facial expressions are communication channels by which people inform others about their feelings and state [15]. Facial expressions of pain provide vital information about the presence of threat in the environment, increasing alertness about occurrence of danger and improving the efficacy of defensive reaction [13,34,40]. In addition to improving self-protective responses, observation of pain in another person can elicit empathic responses that may encourage altruistic behavior of the observer toward the person in pain [22]. The current study sought to further examine how attention to the level of pain, rather than to movements, in expressions primes observers' pain systems.

Brain imaging studies have shown that observation of others' pain expressions activates brain areas associated with the human mirror neuron system, the affective processing of pain, and in the theory of mind [7,33]. Budell et al. showed that attention to the level of pain in expressions is associated with stronger activation in brain areas associated with the extraction of meaning from expressions (ie, ventral-inferior-frontal gyrus and medial-prefrontal cortex), whereas attention to facial movements is associated with greater activation in movement-related brain areas

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(eg, inferior-parietal lobule and premotor cortex). This research suggested that processing of pain in others' expressions recruits regions involved in the affective coding of pain and motor mirroring and demonstrated that the relative engagement of different parts of these networks is under the influence of top-down mechanisms.

Consistent with the perception-action model of empathy [22], previous studies showed that the passive viewing of pain expressions immediately before the delivery of painful electrical stimuli increases pain ratings [19,32]. Moreover, observation of dynamic pain expressions produces a facilitation of the nociceptive flexion reflex (NFR) [19], an automatic withdrawal response generated by spinal nociceptive circuits [29]. These effects demonstrate a vicarious facilitation of pain-related processes involving the priming of defensive/protective responses and reflecting a fundamental adaptive function of pain communication. Unexpectedly, this vicarious facilitation effect was lower in individuals with higher levels of dispositional empathy [19,32]. This may reflect a self/other bias with attention resources spontaneously directed more strongly toward the other person's suffering in highly empathic individuals, resulting in less vicarious facilitation, and toward the self in low empathic individuals, resulting in more vicarious facilitation. These individual biases were observed in conditions involving the passive viewing of pain faces and may be strongly dependent on task demands.

This study investigated the effect of attentional modulation on the vicarious facilitation of responses to pain. We compared pain ratings and RIII reflexes induced by electrical stimuli when participants attended to the amount of pain in facial displays as compared with when they attended to the facial movements [7]. We hypothesized that the explicit processing of a pain expression would enhance vicarious pain effects through a generalized priming of self-pain responses (ie, pain resonance effect). However, based on nonspecific motor priming processes, we also considered the alternative possibility that attention to motor features of pain expression might facilitate the NFR (ie, motor priming effect). Finally, based on the effects of dispositional empathy previously observed (ie, self/other attention bias), we considered the possibility that attention directed at the meaning of pain expressions might reduce vicarious facilitation effects.

2. Methods

2.1. Participants

Thirty-three healthy English-speaking individuals were recruited through advertisements posted in public places (research center and university) and on social websites. Exclusion criteria were verified in the recruitment process and at the beginning of the testing session, and included a history of chronic pain, neurological problems, and current pain before the test. Participants were asked not to take analgesics 24 hours before testing. One participant was removed from analyses after the testing session when he indicated that he had omitted to report the presence of musculoskeletal pain before and during the test session. The remaining 32 participants (16 female) had a mean ± SD age of 25.8 ± 6.1 years (range 18 to 45). The study was approved by the ethics committee of the Centre de Recherche de l'Institut Universitaire de Gériatrie de Montréal (CRIUGM; CMER-RNQ_12-13-08).

2.2. Electrocutaneous stimulation and NFR

The NFR was elicited by a series of 10 square-wave electrical stimuli (1-ms stimulus duration and 2-ms interstimulus interval, resulting in a total stimulation duration of 30 ms) at the distal end of the sural nerve. Stimulation was applied to the retromalleolar site (cathode proximal) of the sural nerve using two 1-cm bipolar surface electrodes.

Muscle reflex activity (RIII reflex) was recorded from the brevis head of the ipsilateral biceps femoris muscle using 2 recording electrodes (EL503, BIOPAC; interelectrode distance 4 cm) placed on the previously cleaned, shaved (if necessary), and abraded skin in order to reach an impedance of <10 kΩ. A third electrode was used as a ground and placed on the medial side of the tibial tuberosity.

The flexion reflex threshold was determined for each participant using the staircase method by increasing and decreasing stimulus intensity in 1.0- and 0.5-mA steps (at least 3 stimuli per intensity, and at least 6 seconds between 2 consecutive stimuli) [19,32]. The NFR threshold was defined as the lowest stimulus intensity evoking a stable RIII response (ie, a clearly detectable response in more than 80% of the trials), according to the classic work of Willer [38,39]; see the review by Sandrini [29]. The stimulus intensity was then increased to 135% of the NFR threshold or until participants rated the electrocutaneous pain as 70 on the 0 to 100 visual analogue scale (VAS) of pain intensity. The mean (± SD) stimulus intensity for the 32 participants in this study was 11.9 mA (± 4.5; range 4 to 24). The mean rating of pain intensity was 54.9 (± 10.6; range 35 to 70).

2.3. Facial expressions

Thirty-two video clips of 1-second dynamic facial expressions (without sound) from 8 actors (4 female) were extracted from a validated database [31]. The selected clips were the same as those used in a previous brain imaging study [7]. Four video clips were taken from each actor expressing the following 4 pain intensity levels: nonpain (neutral), mild pain, moderate pain, and strong pain. Videos were presented in black and white over a gray background.

2.4. Task

The task used in this study was an adapted version of the task used in a previous study by Budell et al. [7] designed to manipulate the subject's attention to the amount of pain conveyed in facial expressions as contrasted with attention directed to the constituent facial movements in the same stimuli in separate trials (Fig. 1).

The task started with a central fixation cross. After 1 second, this cross was replaced by a cue word "Pain" or "Movement". Cue words were presented for 2 seconds and then replaced by a facial expression. In half of the "Pain" cued trials and in half of the "Movement" cued trials, the facial expression was immediately followed by a painful electrical stimulus.

In the "Movement" cued trials without electrical stimulation, participants were instructed to attend to the movements in the facial expression. That is, they had to compare the facial movements in the upper part of the face (around eyes) with the facial movements in the lower part of the face (around mouth). At the offset of the facial expression, a 100-mm VAS appeared anchored by "Eyes" at the left end and by "Mouth" at the right end. Participants had to indicate the relative amount of movement perceived in the upper vs lower part of the face.

In the "Pain" cued trials without electrical stimulation, participants were instructed to attend to the amount of pain in the facial expression. At the offset of the facial expression, a VAS appeared anchored by "No pain at all" at the left end and by "Worst imaginable pain" at the right end. Participants had to rate the amount of pain expressed in the face.

In the trials during which an electrocutaneous stimulus was presented, this stimulation was followed by a VAS anchored by "Not painful at all" at the left end and by "Extremely painful" at