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The anticipation of pain at a specific location of the body prioritizes tactile stimuli at that location

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ABSTRACT

This study investigated whether one becomes more quickly aware of innocuous somatosensory signals at locations of the body where pain is anticipated. Undergraduate students (N = 20) indicated which of 2 stimuli that were administered to each hand using a range of stimulus onset asynchronies (SOAs), was presented first. Participants were instructed that the color of a cue (1 of 2 colors) signaled the possible occurrence of pain on 1 hand (threat trials). The other color of the cue signaled that no pain would follow (control trials). Results showed that during threat trials tactile stimuli on the hand where pain was expected, were perceived earlier in time than stimuli on the "neutral" hand. These findings demonstrate that the anticipation of pain at a particular location of the body resulted in the prioritization in time of somatosensory sensations at that location, indicating biased attention towards the threatened body part. The value of this study for investigating hypervigilance for somatosensory signals in clinical populations such as patients with chronic lower back pain is discussed.

1. Introduction

Attention is a central component in pain theories aiming to explain amplified pain perception, disability, and distress [4,10,12,19,30]. Influential is the idea that patients with chronic pain are characterized by hypervigilance, referring to a preoccupation with bodily threat signals as a result of which attention prioritizes pain-related information at the cost of other environmental demands [8,32]. A recent meta-analysis [9] of studies measuring attentional prioritization of pain-related information indicated that the available evidence supporting this idea is weak. However, the paradigms typically used in these studies may not be suitable to activate pain schemata/memories, as they only assess the prioritization of pain-related words or pictures, and not of pain or somatosensory stimuli. Hence, the use of somatosensory attention paradigms has been recommended [9,30]. The present study is a step into this endeavor.

If fearful anticipation of pain leads to heightened attention to pain-related information [8,12,30], we hypothesized that this would result in the prioritization of – even innocuous – somatosensory input at body locations where pain is expected to occur. Indeed, according to Titchener's [24] law of prior entry, stating that attended stimuli come to consciousness more quickly than unattended stimuli (see [21]), we may expect that one becomes more quickly aware of somatosensory stimuli in a particular location of the body where pain is expected, relative to somatosensory stimuli in other regions of the body. Evidence for our hypothesis is limited as yet. In a study by Crombez and colleagues [6], healthy volunteers were led to believe that a very intense, almost intolerable painful stimulus could occur at 1 particular location of the body. As a result, a mildly painful stimulus at that particular location interfered more with the performance of an ongoing, cognitive task, than pain stimuli at another location [6]. However, no studies have investigated whether the anticipation of pain makes one more quickly aware of non-painful somatosensory information in the threatened body part relative to other body parts.

The aim of the present study was to specifically test this idea. We investigated in healthy persons whether the anticipation of (experimentally induced) pain in 1 hand results in a prioritization of innocuous tactile stimuli at that hand, using a tactile Temporal Order Judgment (TOJ) task [22]. Participants were required to report which 1 of 2 tactile stimuli, 1 administered to each hand at a range of different stimulus onset asynchronies (SOAs), was perceived first. Performance on this task provides information about which hand is prioritized by attention (see [21,28]). Participants were instructed that the color of a cue (1 of 2 colors) signaled the possible occurrence of pain on 1 hand (threat trials). The other color of the cue signaled that no pain would follow (control trials). We hypothesized that in

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threat trials tactile stimuli would be perceived earlier in time on the hand where pain was expected than on the "neutral" hand.

2. Method

2.1. Participants

Twenty undergraduate psychology students (19 female and 1 male; mean age 18.3 years; all white Caucasian) participated to fulfill course requirements. All participants had normal or corrected-to-normal vision and normal hearing. All but 2 were right-handed as reported by self-report. Sixteen participants reported experiencing pain during the previous 6 months (average of 12 days in 6 months). Seven participants reported feeling pain at the moment of testing, but the average rating of the intensity of the pain for these 7 participants was low (M 2.29, SD 1.38) on a Likert scale where 0 indicated "no pain" and 10 "worst pain ever." Participants rated their general health on average as "very good," and none of the participants reported having a current medical or mental disorder. All participants gave informed consent and were free to terminate the experiment at any time. The study protocol was approved by the Ethics Committee of the Faculty of Psychology and Educational Sciences of Ghent University. The experiment lasted for approximately 1 hour and 15 minutes.

2.2. Apparatus and stimulus material

Tactile stimuli (10 ms duration; 200 Hz) were presented by means of 2 resonant-type tactors (C-2 TACTOR, Engineering Acoustics, Inc, Somerville, MA, USA, http://www.eaiinfo.com/) consisting of a housing of 3.05 cm diameter and 0.79 cm high, with a skin contactor of 0.76 cm diameter. Prior to the start of the experiment, the perceived stimulus intensities at both tactor locations were individually matched [33]. This was done by means of a double random staircase procedure, based on the "simple up-down method" of Levitt [13]. In a first phase, 24 stimuli presented on the left hand were judged relative to a reference stimulus with maximum intensity (power = 0.21 W) on a 5-point Likert scale ranging from 1 ("no sensation") to 5 ("maximum intensity"). The intensity that elicited an averaged rating of 3 was used as the stimulus intensity for the left hand, and was the reference stimulus for the second phase. In the second phase, 24 stimuli on the right hand were judged relative to the reference stimulus on the left hand on a 5-point Likert scale (1 = "more than less strong," 2 = "less strong," 3 = "equally strong," 4 = "stronger," 5 = "much stronger"). The intensity that elicited an averaged rating of 3 was used as the intensity of the stimulus at the right hand.

Painful stimuli were electrocutaneous stimuli delivered by constant current stimulators (Digitimer DS5 2000, Digitimer Ltd., Welwyn Garden City, UK, http://www.digitimer.com/index.htm). Electrocutaneous stimuli consisted of trains of 20 ms sinusoid pulses with a frequency of 50 Hz, and were delivered via 2 lubricated Fukuda standard Ag/AgCl electrodes (1 cm diameter) for 200 ms. Intensity of the electrocutaneous stimuli was determined for each participant individually by means of a random staircase procedure. For each hand, 20 electrocutaneous stimuli were presented to participants (start intensity between 0 and 1.5 mA) and self-reports were collected on an 11-point Likert scale (0 = "no sensation"; 10 = "unbearable pain"). The pain intensity that elicited an average rating of 7 was selected as the pain stimulus for the proper experiment [1].

2.3. Tactile Temporal Order Judgment paradigm

The task was programmed and controlled by the INQUISIT Millisecond software package (Inquisit 3.0, Millisecond Software LLC, Seattle, WA, http://www.millisecond.com/) on a laptop (HP Compaq nc 6120). Each trial began with a fixation cross (1000 ms) in the middle of the screen, followed by a colored cue (1000 ms), indicating whether or not a painful electrocutaneous stimulus could follow on 1 hand. A yellow rectangle (10 by 10 cm) indicated that no electrocutaneous stimulus would follow (control trials). A blue rectangle (10 by 10 cm) indicated that a painful electrocutaneous stimulus on 1 hand could follow (threat trials). In 10% of all threat trials, the pain stimulus was actually delivered instead of the 2 tactile stimuli. Participants were not informed about the proportion of pain stimuli. On trials without pain stimulus (90% of threat trials and all control trials), 2 tactile stimuli were administered, 1 on each hand. These stimuli were separated in time by 1 of 10 randomly assigned stimulus onset asynchronies (SOAs) ranging from −120 to +120 ms (−120, −60, −30, −15, −5, +5, +15, +30, +60, +120 ms; negative values indicate that the left hand was stimulated first) [see also 14,27]. Participants were asked to report aloud on which hand the tactile stimulus was presented first. When a pain stimulus replaced a tactile TOJ trial, participants were informed that no response had to be given. Responses were coded by the experimenter using a keyboard.

2.4. Procedure

Participants were tested individually. First, the TOJ task was explained to the participants. They were also informed that an electrocutaneous stimulus would be used during the experiment and that "most people find this kind of stimulation unpleasant." After participants gave their informed consent, they were seated in front of the experimental apparatus. The forearms were positioned symmetrically on the table. The tactors were placed on the metacarpal of each hand. Electrodes were attached to both hands between thumb and index finger, in the sensory territory of the superficial radial nerve. The skin at the electrode sites was first abraded with a peeling cream (Nihon Kohden, Tokyo, Japan) to reduce skin resistance. Participants were instructed that the color of a cue (1 of 2 colors) signaled the possible occurrence of pain on 1 hand. The other color of the cue signaled that no pain would follow. Before the start of each block, participants were informed on which hand (left or right) they could expect painful stimuli. Participants had to report aloud which 1 of 2 tactile stimuli, 1 administered to each hand was presented first. Accuracy of participants' responses was emphasized, rather than speed. Participants wore headphones (Wesc, Conga, Stockholm, Sweden) during the experiment. White noise (42.2 dB) was presented continuously through the headphones to mask the noise resulting from the operation of the tactors. The participants were not given any feedback about their performance.

The session began with a practice block of 23 trials (1 trial per SOA for control trials; 1 trial per SOA for threat trials; 3 electrocutaneous trials). Following this, 4 blocks of 105 trials (5 trials per SOA for control trials; 5 trials per SOA for threat trials, 5 pain trials) were randomly presented with the 2 possible locations of pain (left hand or right hand) alternating between blocks and counterbalanced between participants.

2.5. Self-report measures

After each test phase, participants had to rate several questions about concentration ("To what extent have you made an effort to this task?", "To what extent did you concentrate on this task?"), attention to painful/tactile stimuli ("To what extent did you pay attention to the painful/tactile stimuli?"), pain experience ("How painful did you find the electrocutaneous stimuli?"), anxiety ("How anxious were you during this block?"), fatigue ("To what extent did you find this task tiring?") on an 11-point numerical rat-