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Can Experimentally Induced Positive Affect Attenuate Generalization of Fear of Movement-Related Pain?

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Abstract: Recent experimental data show that associative learning processes are involved not only in the acquisition but also in the spreading of pain-related fear. Clinical studies suggest involvement of positive affect in resilience against chronic pain. Surprisingly, the role of positive affect in associative learning in general, and in fear generalization in particular, has received scant attention. In a voluntary movement paradigm, in which one arm movement (reinforced conditioned stimulus [CS+]) was followed by a painful stimulus and another was not (unreinforced conditioned stimulus [CS–]), we tested generalization of fear inhibition in response to 5 novel but related generalization movements (GSs; within-subjects) after either a positive affect induction or a control exercise (Group = between-subjects) in healthy participants (N = 50). The GSs' similarity with the original CS+ movement and CS– movement varied. Fear learning was assessed via verbal ratings. Results indicated that there was an interaction between the increase in positive affect and the linear generalization gradient. Stronger increases in positive affect were associated with steeper generalization curves because of relatively lower pain–unconditioned stimulus expectancy and less fear of stimuli more similar to the CS–. There was no Group by Stimulus interaction. Results thus suggest that positive affect may enhance safety learning through promoting generalization from known safe movements to novel yet related movements. Improved safety learning may be a central mechanism underlying the association between positive affect and increased resilience against chronic pain.

***Perspective:** We investigated the extent to which positive affect influences the generalization (ie, spreading) of pain-related fear inhibition in response to situations similar to the original, pain-eliciting situation. Results suggest that increasing positive affect in the acute pain stage may limit the spreading of pain-related fear, thereby potentially inhibiting transition to chronic pain conditions.*

***Key words:** Fear of movement-related pain, positive affect, best positive self, fear generalization, voluntary movement paradigm, safety signal.*

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Fear-avoidance models have identified pain-related fear as a key psychological factor involved in the transition from acute to chronic pain disability.[1,10,11,27,28] However, in chronic pain patients, fear is often not restricted to movements associated with pain during the initial pain episode, but rather generalizes (ie, spreads) to similar novel stimuli.[12,18,20] Recent experimental research suggests that overgeneralization of fear of other stimuli may be particularly immobilizing, more so than intense fear of the initial trigger.[13,15] To illustrate, developing fear of all furry animals after being bitten by a poodle is more incapacitating for daily-life functioning than is intense fear of that particular poodle.

In a typical fear conditioning experiment, a neutral stimulus is paired with an aversive stimulus. A recent

study investigated pain-related fear generalization in a paradigm in which one arm movement (the reinforced conditioned stimulus; CS+) was followed by pain (the unconditioned stimulus; US), and another movement was not (the unreinforced conditioned stimulus; CS–).[18] Results indicated that pain-related fear generalized selectively to novel movements that were more similar to the original CS+ than to the CS–, thus for the first time showing a generalization gradient for fear of movement-related pain (ie, a linear increase in fear from CS– to CS+ via the intermediate stimuli).

Fear-avoidance models acknowledge negative affect (NA; the experience of unpleasant emotions such as sadness or anxiety) as an important factor in the development of pain-related fear.[27] Remarkably, both fear-avoidance models and fear conditioning research have paid only scant attention to the role of positive affect (PA; the experience of pleasant emotions such as joy or gratitude).[25] This lack of research is surprising because PA is known to be involved in more adaptive coping and in undoing the psychological and cardiovascular consequences of stress.[4,5] In addition, PA and NA arguably represent different subsystems, rather than opposite endpoints of a single affective continuum.[21] Consequently, the effects of PA cannot be assumed to be exactly opposite to the effects of NA. Accordingly, Zautra and colleagues have found that fibromyalgia patients display a lack of PA but not a surplus of NA during pain and stress, compared to healthy controls.[29] A study on chronic pain patients found that PA was inversely related to pain ratings in subsequent weeks.[30] Meulders and colleagues[16] found that trait PA was associated with different safety learning patterns under extinction (ie, when the pain-US was omitted). Participants with relatively low trait PA were less sure that the previously safe CS– was still safe, compared to participants with relatively high trait PA, indicating failure of fear inhibition.[17]

To our knowledge, no studies have investigated the association between PA and generalization of pain-related fear of other stimuli. This relationship is of particular interest given the possibility that unrestrained spreading of fear is also due to failure to inhibit fear responses. A better understanding of how PA influences generalization is important to optimize prevention and treatment strategies for patients with disabling chronic pain.

Therefore, we aimed to investigate the role of experimentally induced PA on the generalization of pain-related fear. In a voluntary movement joystick paradigm, one arm movement (CS+) was selectively paired with pain, whereas another was not (CS–). After acquisition but before test of generalization (presentation of 5 novel movements; generalization stimuli [GSs]), participants completed either a PA induction or a control exercise. Following the above-mentioned evidence for improved safety learning, we hypothesized that stronger increases in PA would more strongly inhibit generalization of expectancy and fear of pain to stimuli that are more similar to the original CS–, thereby resulting in steeper generalization gradients.

Methods

Participants

Fifty healthy females (mean [M] age = 20.32 years, standard deviation [SD] = 1.97, range = 18–26) freely chose their more valued compensation (course credit or financial compensation) for their participation: 1) 37 psychology students of the University of Leuven received course credits, and 2) 13 volunteers were paid €15. Participants confirmed not being pregnant and not having respiratory or cardiovascular diseases, neurologic diseases (eg, epilepsy), or any other minor or major illness, including chronic pain. Participants were randomly allocated to either the PA induction group (n = 25) or the control group (n = 25), stratified by hand preference (left/right). Seven of 50 participants were left-handed. Additional exclusion criteria were uncorrected hearing problems and pain at the dominant hand or wrist. The experimental protocol was approved by the Ethical Committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (registration number: S-54568) and the Medical Ethical Committee of the University Hospital of the University of Leuven (registration number: ML8513). All participants provided informed consent, which explicitly stated that they were allowed to decline participation at any time during the experiment.

Stimulus Material

The pain-US was a nociceptive electrocutaneous stimulus (square wave form, wavelength 100 λ). Electrical stimulation was administered by a commercial constant current stimulator (DS5; Digitimer, Welwyn Garden City, England) through surface SensorMedics (Homestead, FL) electrodes (8 mm) filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ). The electrodes were attached to the wrist of the dominant hand. The location of the stimulation site remained the same throughout the experiment. During the calibration procedure, participants received a series of electrocutaneous stimuli of increasing intensity and were asked to indicate how painful each stimulus was on a scale ranging from 1, "I feel something but this is not painful, it is merely a sensation"; 2, "This sensation starts to be painful, but it is still a very moderate pain"; up to 10 "This is the worst tolerable pain I can imagine." Participants were told that a subjective stimulus intensity of 8, which refers to a stimulus that is "significantly painful and demanding some effort to tolerate," was targeted. Intermediate digits were displayed without labels. Mean subjective stimulus intensity was 7.72, SD = .72, range = 5–9.

Two proprioceptive stimuli (ie, moving a Paccus Hawk [Paccus Interfaces BV, Almere, The Netherlands] joystick to the left or to the right with an upward angle of 30°) served as conditioned stimuli (CSs). During acquisition, one movement direction (CS+) was followed by the pain-US in 75% of the trials (ie, 75% reinforcement), whereas the other movement direction was never followed by the pain-US (CS–); which movement direction served as CS+ or CS– was counterbalanced across