American Pain Society
RESEARCH
EDUCATION
TREATMENT
ADVOCACY
PUBLISHED BY ELSEVIER

The Journal of Pain, Vol 16, No 12 (December), 2015: pp 1353-1365
Available online at www.jpain.org and www.sciencedirect.com

Comparing Counterconditioning and Extinction as Methods to Reduce Fear of Movement-Related Pain

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Abstract: **Cognitive-behavioral treatments for chronic pain typically target pain-related fear; exposure in vivo is a common treatment focusing on disconfirming harm expectancy of feared movements. Exposure therapy is tailored on Pavlovian extinction; an alternative fear reduction technique that also alters stimulus valence is counterconditioning. We compared both procedures to reduce pain-related fear using a voluntary joystick movement paradigm. Participants were randomly allocated to the counterconditioning or extinction group. During fear acquisition, moving the joystick in 2 directions (conditioned stimulus [CS+]) was followed by a painful electrocutaneous stimulus (pain-unconditioned stimulus [US]), whereas moving the joystick in 2 other directions was not (CS−). During fear reduction, 1 CS+ was extinguished, but another CS+ was still followed by pain in the extinction group; in the counterconditioning group, 1 CS+ was extinguished and followed by a monetary reward-US, and another CS+ was followed by both USs (pain-US and reward-US). The results indicate that counterconditioning effectively reduces pain-related fear but that it does not produce deeper fear reduction than extinction. Adding a reward-US to a painful movement attenuated neither fear nor the intensity/unpleasantness of the pain. Both procedures changed stimulus valence. We contend that changing the affective valence of feared movements might improve fear reduction and may prevent relapse.**

Perspective: ***This article reports no immediate differences between counterconditioning and extinction in reducing pain-related fear in the laboratory. Unexpectedly, both methods also altered stimulus valence. However, we cautiously suggest that methods explicitly focusing on altering the affective valence of feared movements may improve the long-term effectiveness of fear reduction and prevent relapse.***

Key words: *Fear of movement-related pain, fear learning, extinction, counterconditioning, chronic pain, fear-avoidance.*

Received March 10, 2015; Revised August 13, 2015; Accepted September 5, 2015.

A.M. is a postdoctoral researcher of the Research Foundation–Flanders (FWO-Vlaanderen), Belgium (grant ID: 12E33714N). This study was also supported by an EFIC-Grünenthal Research Grant to A.M. (E-G-G ID: 169518451). The contribution of P.A.K. was supported by a Veni Grant (grant ID: 453-04-003) provided by the Netherlands Organization for Scientific Research. The contribution of N.C. was supported by a research grant of the Research Foundation–Flanders (FWO-Vlaanderen), Belgium (grant ID: G091812N). The contribution of J.W.S.V. was supported by the Odysseus Grant "The Psychology of Pain and Disability Research Program" funded by the Research Foundation–Flanders (FWO-Vlaanderen), Belgium (grant ID: G090208N). The authors report no conflict of interest.

Supplementary data accompanying this article are available online at www.jpain.org and www.sciencedirect.com.

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1526-5900/$36.00

http://dx.doi.org/10.1016/j.jpain.2015.09.007

Pain is considered an unconditioned stimulus (US) that demands instantaneous defensive action such as withdrawal from the nociceptive stimulus.[21,57] In addition, neutral movements (conditioned stimulus [CS]) that are associated with pain come to elicit fear and tend to be avoided (conditioned response [CR]). Recent experimental research[38,39,41] demonstrated the involvement of associative learning in the acquisition of fear of movement-related pain.

In the same vein, models of classic conditioning predict that fear of movement-related pain can be reduced using an extinction procedure, that is, exposure to the CS without presenting the US.[3,11] Graded exposure in vivo (GEXP) is the clinical analog of Pavlovian extinction: patients with chronic pain are gradually exposed to feared movement(s) without experiencing

the expected bodily damage.[32,40,62] As a result, patients' catastrophic representation of pain associated with the feared activity is challenged and disconfirmed. Although GEXP is an effective approach to reduce pain-related fear,[2,17-20] there is room for improvement. What patients learn during exposure often does not sufficiently generalize to other situations and contexts.[15,26] Human fear conditioning models predict this relapse. Particularly, with the study of return-of-fear phenomena such as renewal (ie, return of fear after a context switch), reinstatement (ie, return of fear after unpredictable USs), Bouton[4,5] showed that conditioned fear can reemerge after extinction, thus demonstrating that the original CS-US association was not erased but that extinction memory is context dependent.

One possible source of relapse is the lingering, negative, affective valence of feared movements after exposure therapy. That is, patients may still find a certain movement unpleasant, although they no longer avoid it because they have learned that the movement does not provoke bodily harm. Dirikx and colleagues[22] showed that negative stimulus valence plays a role in fear reinstatement after successful extinction.

A counterconditioning procedure can be used to change the stimulus valence. During counterconditioning, a CS is paired with another US of opposing valence.[16,27,30] As a result, the CS starts to elicit CRs in correspondence with the second US, different from its first-learned CR. Raes and De Raedt[45] showed that counterconditioning, in contrast to extinction, can alter the negative stimulus valence of a CS that was previously followed by an aversive US. Following this reasoning, feared movements may no longer elicit fear and avoidance and even lose their negative valence when paired with a nonpainful approach-related stimulus.

We compared both extinction and counterconditioning as procedures to reduce fear of movement-related pain using a voluntary joystick movement (VJM) paradigm[39] with arm movements as CSs and a painful electrocutaneous stimulus as the negative valenced US (pain-US). We operationalized the positive valenced US as a monetary reward (reward-US); in humans, money is considered a salient secondary US that has received its positive valence by cultural transmission. Participants were randomly allocated to the counterconditioning (COUNTER) group or the extinction (EXT) group. In both groups, 2 CS+ movements were followed by the pain-US, whereas 2 CS− movements were not followed by pain during fear acquisition. Then, 1 CS+ was extinguished, but another CS+ was still followed by pain in the EXT group. In the COUNTER group, 1 CS+ was followed by the reward-US (ie, counterconditioning), and another CS+ was followed by both USs (ie, competition). We hypothesized that: 1) counterconditioning is effective in reducing pain-related fear and 2) leads to deeper fear reduction than extinction, 3) a concurrent reward-US during a painful movement attenuates pain-related fear, 4) a concurrent reward-US attenuates intensity and unpleasantness of a painful stimulus, and 5) counterconditioning but not extinction renders the valence of the CSs more positive.

Methods

Participants

Fifty healthy individuals (21 males and 29 females; mean ± standard deviation [SD] age = 23 ± 5.27 years) participated in this study and were reimbursed in 2 ways: 1) 3 first-year psychology students received 1.5 course credits and 2) the 47 other volunteers received €12. Exclusion criteria were pregnancy; past or current severe medical conditions, psychiatric disorders or chronic pain; having received the advice to avoid stressful situations from a general practitioner; cardiac pacemaker or presence of any other medical device; acute pain or impairment at the dominant hand or wrist; uncorrected hearing problems. The study was approved by the ethics committee of the Faculty of Psychology and Educational Sciences of the University of Leuven (registration number: S-55375). All participants signed the informed consent form, which emphasized that they could withdraw from the study at any time. Participants were randomly assigned to 1 of the 2 experimental groups (EXT or COUNTER group).

Stimulus Material

Four proprioceptive stimuli (ie, moving a Logitech Attack3 joystick [Logitech International S.A., Lausanne, Switzerland] upward, downward, to the left, and to the right) were used as CSs. Participants performed the movements by manipulating the joystick with their dominant hand. The first US was an electrocutaneous stimulus (duration of 2 milliseconds), administered by a commercial stimulator (DS7A; Digitimer, Welwyn Garden City, UK) through surface Sensormedics electrodes (8 mm; SensorMedics Corporation, San Diego, CA) filled with KY gel (Johnson & Johnson, New Brunswick, NJ) that were attached to the wrist of the dominant hand. The pain-US intensity level was individually selected during a preexperimental calibration procedure. During this procedure, participants received a series of pain-USs of increasing intensity. After each stimulus presentation, they rated the intensity of that stimulus on a rating scale from 1 to 10, with 1 meaning "You feel something, but this is not painful; it is merely a sensation" and 10 meaning "This is the worst pain you can imagine." Participants indicated if they did not want to receive a stimulus of higher intensity or if they wanted the intensity to be set back to a lower level, yet they were asked to try to select a significantly painful and unpleasant stimulus. We targeted a pain-US of a subjective intensity of 8, which corresponds to a stimulus that is "significantly painful and demanding some effort to tolerate." The pain-US intensity remained unchanged throughout the experiment. The second US we used was a monetary reward. The reward-US was represented by a € symbol on the computer screen. Participants received written instructions explaining that the presentation of a € symbol on the computer screen (ie, reward-US) during a given trial represented an extra monetary profit of €.50. In total, the reward-US was presented on 32 trials in the COUNTER group so that participants in that