Recent research suggests that the mere intention to perform a painful movement can elicit pain-related fear. Based on these findings, the present study aimed to determine whether imagining a movement that is associated with pain (CS+) can start to elicit conditioned pain-related fear as well and whether pain-related fear elicited by imagining a painful movement can spread towards novel, similar but distinct imagined movements. We proposed a new experimental paradigm that integrates the left-right hand judgment task (HJT) with a differential fear conditioning procedure. During Acquisition, one hand posture (CS+) was consistently followed by a painful electrocutaneous stimulus (pain-US) and another hand posture (CS-) was not. Participants were instructed to make left-right judgments, which involve mentally rotating their own hand to match the displayed hand postures (i.e., motor imagery). During Generalization, participants were presented with a series of novel hand postures with six grades of perceptual similarity to the CS+ (generalization stimuli; GSs). Finally, during Extinction, the CS+ hand posture was no longer reinforced. The results showed that (1) a painful hand posture triggers fear and increased US-expectancy as compared to a nonpainful hand posture, (2) this pain-related fear spreads to similar but distinct hand postures following a generalization gradient, and subsequently, (3) it can be successfully reduced during extinction. These effects were apparent in the verbal ratings, but not in the startle measures. Because of the lack of effect in the startle measures, we cannot draw firm conclusions about whether the “imagined movements” (i.e., motor imagery of the hand postures) gained associative strength rather than the hand posture pictures itself. From a clinical perspective, basic research into generalization of pain-related fear triggered by covert CSs such as intentions, imagined movements and movement-related cognitions might further our understanding of how pain and fear avoidance spread and persevere.

Keywords: pain-related fear; fear conditioning; fear generalization; motor imagery; laterality judgment

According to contemporary fear-avoidance models, pain-related fear plays a pivotal role in the development and maintenance of chronic pain and disability (Crombez, Eccleston, Van Damme, Vlaeyen & Karoly, 2012; Vlaeyen & Linton, 2000,
The occurrence of these behaviors will be intensified and maintained (Fordyce et al., 1973; Fordyce, Shelton, & Dundore, 1982; McCracken & Samuel, 2007; Philips, 1987).

Under normal circumstances pain-related fear would extinguish after healing, when individuals learn that the CS is no longer followed by the painful US. The power of operant conditioning and learned non-use/avoidance, however, may prevent this extinction from occurring (Philips, 1987; Taub, Uswatte, Mark, & Morris, 2006). That is, when avoidance/non-use is established, spontaneous exposure to the CS, which might disconfirm the CS-US association, is prevented.

Furthermore, it is clinically apparent that highly fearful chronic pain patients avoid not only movements and activities that were associated with (increased) pain, through direct experience, but also movements and activities that have not been associated with an initial pain episode. Contemporary models of classical fear conditioning offer a possible explanation for this observation. That is, under certain circumstances, novel stimuli that have features in common with the original fear-eliciting CS may come to evoke a similar CR. By and large, this mechanism, referred to as stimulus generalization (Ghirlanda & Enquist, 2003; Honig & Urciuoli, 1981; Kalish, 1969), is highly adaptive because a healthy balance between discrimination and generalization may assist in avoiding harm in a dynamic environment. Yet, a disturbed balance may give rise to maladaptive defensive behaviors, which is consistent with the persistent and undesired avoidance behavior observed in chronic pain. In our opinion, research into generalization of pain-related fear triggered by covert CSs such as intentions, imagined movements, and movement-related cognitions might further our understanding of how pain and fear avoidance spread and persevere.

In order to investigate the acquisition and generalization of fear of imagined movements, we integrated the left-right hand judgment task (HJT) with a differential fear conditioning procedure. During the acquisition phase, one hand posture picture (CS+) was consistently followed by a painful electrocutaneous stimulus (pain-US) and another hand posture picture (CS-) was not. Participants were instructed to judge whether the hand was a left or a right hand. This task involves mentally moving one’s own hand to match the posture of the hand shown in the image (Parsons, 2001). CS hand posture pictures were presented in four different orientations to maximize the chances that the imagined hand postures, and not the geometric features of the picture, would be associated with the painful outcome. During the generalization phase, participants were presented with a series of novel han
postures with six grades of perceptual similarity to the CS+ (generalization stimuli; GSs), which were presented in the same four orientations. During the HJT, we collected anticipatory US-expectancy ratings, anticipatory pain-related fear ratings, and response latency for the laterality judgments. We also measured eyeblink startle responses while participants made judgments (i.e., motor imagery) and in between judgments (inter-trial interval; ITI). We predicted (a) higher US-expectancy and pain-related fear ratings, as well as higher startle responses for the CS+ than the CS- hand postures and (b) faster response latencies for left-right judgments for the CS+ hand postures than for the CS- hand postures (indicative of an attentional threat bias) during acquisition. We further predicted (c) that these differences in conditioned responding would disappear during the extinction phase, and (d) generalization gradients characterized by higher US-expectancy and pain-related fear ratings for the novel hand pictures that are more similar to the original CS+ than to the original CS-, and a similar gradient for the startle eyeblink and response latency.

Methods

PARTICIPANTS

Fifty healthy participants (41 females; $M_{\text{age}} = 22$ years, $SD_{\text{age}} = 4.23$, range$_{\text{age}} = 18–46$) were recruited by means of flyers and through the university “Experimental Management System” (EMS). Volunteers were paid 12€ or given course credit where applicable and preferred. Participants were psychology students ($n = 23$), nonpsychology university students ($n = 25$) and working members of the community ($n = 2$). Participants completed a health checklist to ensure they did not suffer from respiratory, cardiovascular, or neurological disease and that they were free from chronic pain, psychiatric disorders, other minor or major illnesses or pregnancy. Additional exclusion criteria were uncorrected hearing problems and hand pain. 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-55840) and the Medical Ethical Committee of the University Hospital of the University of Leuven (registration number: ML9745). All participants signed the informed consent form and participants were informed that they were allowed to withdraw from the experiment at any time.

STIMULUS MATERIALS AND MEASURES

The experiment was programmed in Affect 4.0 (Spruyt, Clarysse, Vansteenwegen, Baeyens, & Hermans, 2010) and run on a Windows XP (Microsoft Corporation Redmond, WA, USA) computer (Dell Optiplex 755; Dell Inc., Round Rock, TX, USA) with 2GB RAM and an Intel Core 2 Duo processor (Intel, Santa Clara, CA, USA) at 2.33 GHz and an ATI Radeon 2400 graphics card (Advanced Micro Devices, Sunnyvale, CA, USA) with 256 MB of video RAM. We used (implicitly) imagined movements as conditioned stimuli (CS). To create these imagined movements, we employed a computerized left-right HJT (Parsons, 1987; Parsons et al., 1995), a task in which participants are prompted to judge whether a certain hand picture created with Poser (Smith Micro Software, Productivity and Graphics Division, Watsonville, CA, USA), a 3D animation program, depicts a left or a right hand. To make this judgment, (healthy) people use a set of mental rotations that closely match the operations required for actual hand movements, a process known as “motor imagery.” Evidence has accumulated pointing to a tight similarity between properties of motor imagery and actual movement execution (Parsons, Gabrieli, Phelps, & Gazzaniga, 1998). Furthermore, evidence stemming from neuroimaging studies suggests that comparable brain activation is observed during mental rotation and motor execution (Decety et al., 1994; Gerardin et al., 2000). When participants judge whether the depicted hand is left or right, they typically (a) make an initial judgment, (b) mentally rotate their own body part into the postures of the image, (c) and then confirm or reject their initial judgment. As a result, we can assume that the imagined movement and resulting imagined end posture is unique to the posture of the depicted hand. Based on this knowledge, we decided to use such picture-specific motor imagery to create the distinct covert conditioned stimuli (CS+ and CS-), generalization stimuli (GS), and distractor stimuli (DS) (see Figure 1). The CS+ and CS- were hand postures at the extremes of hand flexion and extension. Whether the flexed or extended hand acted as the CS+ was counterbalanced among participants. Distractor hands were included to prevent the task from being too simple. The GS hand postures were six hand pictures with decreasing perceptual similarity with the CS+ and increasing similarity with the CS- hand postures, whereas the DS were functionally distinct hand postures. In order to associate the imagined movement with the pain-US while restricting the salience of the mere visual (i.e., geometric) properties of the hand picture, each hand picture was presented in four different (3-dimensional) orientations (two medial and two lateral orientations, with each orientation of the CS+ and CS- presented once within each experimental block). The US was a painful electrocutaneous stimulus (2-ms duration), which
was administered via a commercial constant current stimulator (DS7A, Digitimer, Welwyn Garden City, England) through 8 mm surface electrodes (Sensor Medics, Homestead, FL, USA), which were filled with K-Y gel (Johnson & Johnson, New Brunswick, NJ, USA). The stimulation electrodes were attached to the right ankle, so that participants could operate the response box and computer mouse freely with their hands. The electrocutaneous stimulus was set using a calibration procedure consisting of a series of electrical stimuli of increasing intensity. Participants were asked to indicate how painful each electrical stimulus was on a 1–10 numerical rating scale where 1 means: "you feel something but this is not painful, it is merely a sensation"; 2 means: "this sensation starts to be painful, but it is still a very moderate pain"; up to 10, which means: "the worst tolerable pain." A subjective stimulus intensity of 8, which refers to a stimulus that is "significantly painful and demanding some effort to tolerate" was targeted. The mean physical stimulus intensity chosen during the calibration procedure was 33.94 mA (SD = 15.92, range = 8–70); participants rated this stimulus intensity as 8.02 (SD = 0.14, range = 8–9) on the painfulness scale from 1–10, confirming that the selected stimulus was “significantly painful and demanding some effort to tolerate.”

Conditioned fear of pain-related imagined movement was measured through startle eyeblink reflex modulation and self-reports. The startle reflex is a full-body reflex involved in defensive response mobilization. It is very short latency reflex triggered by startle-evoking stimuli (e.g., acoustic startle probe) and is mediated by a brainstem and spinal cord pathway, which is directly and indirectly connected to the amygdala. Electromyographic (EMG) activity of the orbicularis oculi, the muscles underneath the eye, triggered by an acoustic startle probe is often used to measure the eyeblink component of the startle response. Startle modulation refers to the increase or potentiation of the startle reflex during fear states elicited by the anticipation of an aversive stimulus (e.g., an electrocutaneous stimulus). In the present setup, the startle probe was a 100 dB(A) burst of white noise with instantaneous rise time presented binaurally for 50 ms through
headphones. The magnitude of the eyeblink startle responses elicited by the startle probe during imagined movements (i.e., while the participant mentally rotated their hand in in order to make the left-right judgment) served as an index of stimulus-specific pain-related fear. The magnitude of the eyeblink startle responses elicited by startle probes during the ITI served as an index of contextual pain-related fear. Note that in this experiment no pain-USs were delivered during the ITI and thus the context was technically safe. Therefore, we expected low startle responses during the context and thus little or a lack of contextual fear. We measured latency and accuracy of the left-right hand judgments using a custom-made response box with two buttons connected via the parallel port of the computer.

**Procedure**

In a within-subjects experimental design, the left-right HJT was combined with a differential human fear conditioning procedure. The experiment was conducted during a single 80-minute session. The experiment consisted of several phases: Preparation, Practice, Habituation, Acquisition, Generalization, and Extinction. During Acquisition, participants were presented with hand pictures in different postures and they were told that their main task was to judge whether the depicted hand was a left hand or a right hand. They gave their judgments by pressing the corresponding button on the response box. During Acquisition, one of these hand postures was consistently followed by the pain-US (CS+), and another hand posture (CS-) was not. The CS+ and CS- hand postures were at opposite ends of the physiological range of the hand flexion-extension continuum. For half of the participants the extreme flexed hand posture was the CS+ and the extreme extended hand posture as the CS-. For the other half of the participants, these postures were reversed.

**Preparation**

Participants were informed (orally and in writing) that painful electrocutaneous stimuli (pain-US) and loud noises (acoustic startle probes) would be administered during the experiment. After providing informed consent, participants entered the experimental room. The electrodes for eyeblink startle responses were placed on the left side of the face according to the site specifications proposed by Blumenthal et al. (2005). Prior to the attachment of electrodes, the skin was scrubbed using exfoliating peeling cream to reduce interelectrode resistance. Following this, the electrical stimulation electrodes were attached to outside of the right ankle (lateral malleolus) using adhesive collars and the stimulus intensity was set using the previously described procedure (see section “Stimulus Materials and Measures”).

**Practice**

Before starting the combined left-right hand judgment conditioning task, we included a practice phase to train participants to determine “as quickly and accurately as possible” whether a certain hand picture displayed on screen was a left hand or a right hand. During this phase, participants were shown two blocks of 20 hand pictures that were distinct from those used during the experiment. No acoustic startle probes or pain-USs were presented. Participants who failed to achieve 80% accuracy in the second block repeated the practice blocks (each time consisting of 20 different hand pictures) until they achieved 80% or better. Ninety-four percent of the participants went through two practice blocks (of 20 trials) to fulfill the task performance requirements (\(M_{\text{block1}} = 16.02, \ SD_{\text{block1}} = 3.04, \ range = 4–20; \ M_{\text{block2}} = 17.44, \ SD_{\text{block2}} = 1.79, \ range = 12–20\)), whereas 6% needed one extra practice block (\(M_{\text{block3}} = 17.33, \ SD_{\text{block3}} = 1.53, \ range = 16–19\)).

**Habituation**

Since the first acoustic startle probes typically elicit disproportionately high startle responses, a habituation phase, consisting of eight trials of 15 s with an ITI of 5 s, was included. During each 15-s trial, the acoustic startle probe was presented at a random moment between 2–7 s (4 trials) or between 8–13 s (4 trials). During this phase, the participants wore headphones and the lights in the lab were dimmed.

**Acquisition**

The acquisition phase comprised three blocks of 16 trials, each block consisted of 4 CS+ presentations, 4 CS- presentations, and 8 DS presentations. Before starting the experiment, the participants received written instructions about the left-right HJT. Each trial began with the presentation of a fixation cross “+”, prompting the participant to focus his/her attention. After 2,500 ms, a hand picture was presented in the middle of the computer screen until a left-right judgment was made. If no judgment was made within 5,000 ms after the presentation of the picture, a “no response” judgment was recorded and the trial was aborted. Once the hand picture had disappeared, the 10,000 ms ITI commenced. During acquisition blocks 1 and 2, one startle probe was presented on each trial, either during the mental rotation of the hand picture or during the ITI. Normative data suggests that a left-right judgment response takes on average 1.5–2 s (Wallwork et al., 2013). Thus, in order to ensure fear was measured during the imagined movement (and not during
decision making and motor responding), startle probes were delivered 500 ms after picture onset. In trials containing an ITI probe, the probe was delivered 5,000 ms after the end of the previous trial (when the picture disappeared from the screen). In half of the trials, participants were asked to give US-expectancy (“How much do you expect the shock to occur?”) and fear ratings (“How fearful are you at this moment?”). These questions were presented on the screen immediately after the left-right judgment and participants responded on an 11-point (0–10) numerical rating scale anchored at left with “not at all” and at right with “very much.” On such question trials, the hand picture remained on screen until the questions were answered. After participants gave their fear and US-expectancy ratings, the picture disappeared and the ITI was initiated. On CS+ trials without any question, the pain-US was delivered immediately after the laterality judgment (100% reinforcement). If a “no response” was recorded on a CS+ trial, the hand picture automatically disappeared and the pain-US was administered. On CS+ trials with questions, the pain-US was delivered immediately when the questions were answered and the image was withdrawn. Within each block hand pictures were presented in semirandomized order, with the restriction that no more than two hand pictures of the same stimulus type (CS+, CS- or DS) could be presented successively and hand pictures, startle probes and fear and US-expectancy ratings were presented with the restriction that each hand laterality (left and right) and stimulus type was equally distributed in the EMG startle data and self-report measures. Participants were not informed about the contingencies between motor imagery of the hand postures pictures (CSs) and the pain-US. In the third acquisition block fear and US-expectancy ratings were presented on each trial in order to prepare the participants for the generalization phase in which anticipatory ratings were collected during each stimulus presentation as well.

Generalization

During the generalization phase, the procedure was largely identical to the last acquisition block. The difference was that participants now had to perform mental rotations of hand pictures in six novel hand postures. These hand postures varied in perceptual similarity between the CS+ and the CS- and again were presented in four orientations. The generalization phase consisted of 2 blocks of 10 trials consisting of presentations of the original CS+ and CS-, each GS (1–6) as well as two DS presentations. These stimuli were presented in a semirandomized order with the restriction that no more than two consecutive trials could be of the same laterality (left or right), stimulus type (CS+, CS-, GS, and DS), and orientation (medial or lateral) across the two phases.

Extinction

The procedure during the extinction phase was exactly the same as during acquisition with the exception that the CS+ was no longer followed by the pain-US.

MANIPULATION CHECKS

Response Accuracy

Response accuracy provides a method of checking participants were not merely guessing. We set the criterion a priori, that the 95% CI of response accuracy was greater than 50%, which would occur due to chance.

PRIMARY OUTCOME VARIABLES

Anticipatory US-Expectancy and Fear of Pain Ratings

Online US-expectancy and fear of pain were assessed by asking participants to rate to what extent they expected the painful stimulus to occur, and how fearful they were at a given moment. Responses to the questions were given on an 11-point (0–10) numerical rating scale with the anchors “not at all” to “very much.”

Eyeblink Startle Modulation

Orbicularis oculi EMG activity was recorded with 3 Ag/AgCl electrodes (4 mm diameter; Sensor Medics) filled with electrolyte gel. The raw signal was amplified by a Coulbourn isolated bioamplifier (Coulbourn Instruments, Whitehall, PA, USA) with a bandpass filter (LabLinc v75–04). The recording bandwidth of the EMG signal was between 90 Hz and 1 kHz (±3 dB). The signal was rectified online and smoothed by a Coulbourn multifunction integrator (LabLinc v76–23 A) with a time constant of 20 ms. The EMG signal was digitized at 1000 Hz from 500 ms before the onset of the auditory startle probe until 1,000 ms after it.

Response Latency

Response latency, a marker of attentional threat bias, was defined as the time elapsed from the presentation of the hand picture until a key press (i.e., left or right button) on the response box was recorded. “No response” trials (i.e., reaction time > 5,000 ms) were discarded.

EXPERIMENTAL SETTING

Participants were seated in an armchair 60 cm from the screen in a sound-attenuated and dimly lit room, adjacent to the experimenter’s room. Further verbal communication was possible through an intercom system and the participants and their
physiological responses were observed in real time by means of a closed-circuit TV installation and computer monitors.

**DATA EXTRACTION AND STATISTICAL ANALYSIS OVERVIEW**

We calculated the peak startle amplitudes, defined as the maximum of the response curve within 21–175 ms after the startle probe onset, using psychophysiological analysis (PSPHA; de Clercq, Verschueren, de Vlieger, & Crombez, 2006), a modular script-based program. All startle waveforms were visually inspected prior to analysis, and technical abnormalities and artifacts were eliminated using the PSPHA software. Each peak amplitude was scored by subtracting its baseline score (averaged EMG level between 1 ms and 20 ms after the probe onset). The raw scores were transformed to z-scores to account for interindividual differences in physiological reactivity. In order to optimize the visualization of the startle data and avoid negative values on the Y-axis, T-scores—a linear transformation of the z-scores—were used in the figures. Averages were calculated for the startle responses elicited during the CSs, DS, GS (1–6) and the ITI per block.

Response latencies from the practice phase were not analyzed. Trials with reaction times < 500 ms (because then the probe presentation would not have been reliably during the motor imagery) and “no response” trials (i.e., reaction time > 5,000 ms) were discarded. Mean response latencies were calculated for each stimulus type per block.

We carried out a series of repeated measures ANOVAs to test our a priori hypotheses, and we further scrutinized the effects using planned comparisons. The effect size indication $\eta^2_p$ is reported for significant effects. Greenhouse-Geisser corrections were carried out when appropriate. Uncorrected degrees of freedom and corrected $p$-values are reported together with $\epsilon$. All statistical analyses were run using Statistica 12 (StatSoft, Inc, Tulsa, Okla).

**Results**

**MANIPULATION CHECKS**

**Response Accuracy**

We calculated the number of correct answers per phase for the CS+, CS-, DSs, and GSs (when appropriate). During Acquisition, accuracy was 85% for CS+ postures, 95% CI [74.69, 95.06], 84% for CS- postures, 95% CI [74.05, 94.70], and 83% for DS postures, 95% CI [72.01, 93.49]. During Generalization, accuracy was 89% for the CS+, 95% CI [80.09, 97.91], 89% for the CS-, 95% CI [80.09, 97.91], 85% for the DS, 95% CI [74.20, 94.80], and 89% for the GSs, 95% CI [80.13, 97.91]. During Extinction, accuracy was 92% for the CS+, 95% CI [84.04, 99.62], 94% for the CS-, 95% CI [87.50, 100.83], and 90% for the DS postures, 95% CI [81.24, 98.43].

**PRIMARY OUTCOME VARIABLES**

**Anticipatory US-Expectancy Ratings**

**Acquisition effects.** We conducted a $3 \times 3$ [Stimulus Type (CS+/CS-/DS) × Block (a1-3)] RM ANOVA on the US-(expectancy ratings for the different hand postures, averaged per acquisition block (see Figure 3, panel A). There was a significant main effect of stimulus type, $F(2, 98) = 5.81$, $p < .05$, $\epsilon = .61$, $\eta^2_p = .11$, and a significant main effect of block, $F(2, 98) = 6.19$, $p < .01$, $\epsilon = .75$, $\eta^2_p = .11$, indicating that US-expectancy ratings differed depending on whether stimuli where followed by pain and changed across blocks. Of crucial importance, there was a significant Stimulus Type × Block interaction, $F(4, 196) = 5.84$, $p < .01$, $\epsilon = .50$, $\eta^2_p = .11$, suggesting that the differences in US-expectancy ratings for both CSs developed differently during the acquisition phase. Planned comparisons confirmed that participants expected the pain-US more to occur after the CS+ hand postures than after the CS- hand postures, $t(49) = -.49$, $p < .01$, 95% CI [0.72, 2.69]. In addition, participants also reported to expect the pain-US to occur more after the CS+ picture than after the DS pictures, $t(49) = 3.18$, $p < .01$, 95% CI [-2.42, -0.55]. As expected, no significant differences in US-expectancy ratings were observed between the CS- and the DS, $t(49) = -1.31$, $p = .20$, 95% CI [-0.12, 0.56]. (See Fig. 2.)

**Generalization effects.** To examine generalization of US-expectancy to the novel GS hand postures, we ran a $2 \times 9$ [Block (g1-2) × Stimulus Type (CS+/GS1-6/CS-/DS)] RM ANOVA (see Figure 3, panel B). From this analysis a significant main effect of stimulus type, $F(8, 392) = 13.47$, $p < .001$, $\epsilon = .28$, $\eta^2_p = .22$, and a significant main effect of block emerged, $F(1,49) = 13.74$, $p < .01$, $\eta^2_p = .22$. There was no Block × Stimulus Type interaction, $F < 1$. Planned comparisons were used to further test our a priori hypotheses. In line with our hypothesis, there was a significant linear decrease in the US-expectancy ratings with decreasing GS similarity to the CS+ in the first generalization block (g1), $F(1, 49) = 15.03$, $p < .001$, as well as in the second generalization block (g2), $F(1, 49) = 18.62$, $p < .001$. The generalization gradient was further supported by multiple planned comparisons (see Table 1). These comparisons revealed that during both generalization blocks, the difference in US-expectancy between the
CS+ and CS- remained significant, g1: $t(49) = -3.97, p < .001, 95\% CI [1.21, 3.71]$; g2: $t(49) = 4.39, p < .001, 95\% CI [1.41, 3.79]$, as well as the difference in US-expectancy between the CS+ and DS, g1: $t(49) = 4.11, p < .001, 95\% CI [1.17, 3.43]$; g2: $t(49) = 4.36, p < .001, 95\% CI [1.31, 3.57]$. Again, no such differences were observed between the CS- and the DS in either of the generalization blocks, g1: $t(49) = -0.78, p = .43, 95\% CI [-0.56, 2.44]$; g2: $t(49) = -0.66, p = .51, 95\% CI [-0.64, 0.32]$. Furthermore, during the first generalization block, the US-expectancy reported in response to the GS1 did not differ from the CS+, $t(49) = 1.54, p = .13, 95\% CI [-0.15, 1.15]$, and during the generalization second block, there was no significant difference in US-expectancy ratings between the CS+ and GS1, $t(49) = 1.86, p = .07, 95\% CI [-0.06, 1.59]$ and, the CS+ and the GS2, $t(49) = 1.65, p = .11, 95\% CI [-0.17, 1.73]$.

**Extinction effects.** We carried out a $3 \times 3$ [Stimulus Type (CS+/CS-/DS) $\times$ Block (e1-3)] RM ANOVA on the US-expectancy ratings for the different hand postures averaged per extinction block (see Figure 3, panel A). There was a significant main effect of stimulus type, $F(2, 98) = 19.80, p < .001, \eta^2_p = .29$, and a significant main effect of block, $F(2, 98) = 41.64, p < .001, \eta^2_p = .46$, indicating that US-expectancy ratings differed depending on stimulus type and decreased across blocks. In line with our expectations, the crucial Stimulus Type $\times$ Block interaction

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**FIGURE 2** Overview of an illustrative trial timing of a CS+ trial. Note that the square represents the white noise signal used as the acoustic startle probe, the lightning bolt represents the pain-US. During acquisition and extinction, only one startle probe was delivered per trial, either during mental rotation of the picture (i.e., cued pain-related pain) or in the ITI (i.e., contextual pain-related fear). On 50% of the trials, participants rated their anticipatory pain-related fear and US-expectancy before the pain-US was delivered and/or the ITI was initiated. During the generalization phase, two startle probes were presented per trial (one during the mental rotation of the picture and one during the ITI) and pain-related fear and US-expectancy ratings were asked on each trial (100%).

**FIGURE 3** Mean anticipatory US-expectancy ratings A, for the CS+, CS- and distractor stimuli (DSs) separately during the three acquisition blocks (a1-3), and B, for the CS+, CS-, the DSs and the six generalization stimuli (GS1-6) separately during both the generalization blocks (g1-2) (lower panel). Vertical bars denote standard errors.
A. Anticipatory US-expectancy during acquisition and extinction

B. Anticipatory US-expectancy during generalization
emerged, $F(4, 196) = 3.54, p < .05, \varepsilon = .67, \eta^2_p = .07$, suggesting that the differences in US-expectancy ratings for both CSs developed differently during the extinction phase. Furthermore, there was a significant decline in the differences in US-expectancy for the CS+ vs. CS- from the beginning of the extinction phase compared with the end of the extinction phase, $F(1, 49) = 5.95, p < .05$. Planned comparisons revealed at the beginning of the extinction phase (e1), (a) participants still expected the pain-US more to occur after the CS+ hand postures than after the CS- hand postures, $t(49) = 4.58, p < .001$, 95% CI [1.33, 3.41], (b) they reported to expect the pain-US to occur more after the CS+ picture than after the DS pictures, $t(49) = 4.14, p < .001$, 95% CI [-3.22, -1.12], and (c) no significant differences in US-expectancy ratings were observed between the CS- and the DS, $t(49) = -1.24, p = .22$, 95% CI [-0.12, 0.52]. Planned comparisons at the end of the extinction phase (e3) further showed that (a) contrary to our expectations, participants still expected the pain-US more to occur after the CS+ hand postures than after the CS- hand postures, $t(49) = -3.48, p < .01$, 95% CI [0.56, 2.08], (b) they reported to expect the pain-US to occur more after the CS+ picture than after the DS pictures, $t(49) = -3.51, p < .001$, 95% CI [-1.89, -0.51], and (c) no significant differences in US-expectancy ratings were observed between the CS- and the DS, $t(49) = -0.83, p = .40$, 95% CI [-0.17, 0.41].

**Anticipatory Fear of Pain Ratings**

**Acquisition effects.** We ran a $3 \times 3$ [Stimulus Type (CS+/CS-/DS) × Block (a1-3)] RM ANOVA on the pain-related fear ratings for the different hand postures, averaged per acquisition block (see Figure 4, panel A). There was a significant main effect of stimulus type, $F(2, 98) = 3.52, p < .05, \varepsilon = .66, \eta^2_p = .07$, but no main effect of block, $F(2, 98) = 1.76, p = .19, \varepsilon = .75$. Of crucial importance, there was a significant Stimulus Type × Block interaction, $F(4, 196) = 7.07, p < .01, \varepsilon = .58, \eta^2_p = .13$, suggesting that pain-related fear developed differently in response to both CSs during the acquisition phase. Planned comparisons confirmed that participants were more afraid of the CS+ hand postures than the CS- hand postures, $t(49) = -3.32, p < .01$, 95% CI [0.50, 2.04]. In addition, participants also were more afraid of the CS+ hand postures than the DS postures, $t(49) = 2.68, p < .01$, 95% CI [-1.79, -0.26]. As expected, no significant differences in pain-related fear ratings were observed between the CS- and the DS, $t(49) = -1.80, p = .08$, 95% CI [-0.03, 0.52].

**Generalization effects.** To examine generalization of fear towards the novel GS hand postures, we ran a $2 \times 9$ [Block (g1-2) × Stimulus Type (CS+/GS1-6/DS)] RM ANOVA (see Figure 4, panel B). This analysis yielded a significant main effect of stimulus type, $F(8, 392) = 7.86, p < .001, \varepsilon = .26, \eta^2_p = .14$, and a significant main effect of block emerged, $F(1.49) = 13.74, p < .01, \eta^2_p = .22$. There was no Block × Stimulus Type interaction, $F(8, 392) = 1.22, p = .30$. Planned comparisons were used to further test our a priori hypotheses. In line with previous research using movements as generalization stimuli, there was a significant linear decrease in the pain-related fear ratings with decreasing GS similarity to the CS+ in the first generalization block (g1), $F(1, 49) = 9.14, p < .01$, as well as in the

**Table 1**

<table>
<thead>
<tr>
<th>Effect</th>
<th>$t$</th>
<th>df</th>
<th>$p$</th>
<th>95% CI</th>
</tr>
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<tr>
<td>US-expectancy – Generalization Block 1</td>
<td></td>
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<tr>
<td>CS+ vs. CS-</td>
<td>3.97</td>
<td>49</td>
<td>&lt;.001</td>
<td>[1.21, 3.71]</td>
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<tr>
<td>CS+ vs. DS</td>
<td>4.11</td>
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<td>&lt;.001</td>
<td>[1.17, 3.43]</td>
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<tr>
<td>CS+ vs. GS1</td>
<td>1.54</td>
<td>49</td>
<td>.13</td>
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</tr>
<tr>
<td>CS+ vs. GS2</td>
<td>2.86</td>
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<td>&lt;.001</td>
<td>[0.33, 1.87]</td>
</tr>
<tr>
<td>CS+ vs. GS3</td>
<td>3.62</td>
<td>49</td>
<td>&lt;.001</td>
<td>[0.76, 2.64]</td>
</tr>
<tr>
<td>CS+ vs. GS4</td>
<td>3.93</td>
<td>49</td>
<td>&lt;.001</td>
<td>[1.06, 3.30]</td>
</tr>
<tr>
<td>CS+ vs. GS5</td>
<td>3.73</td>
<td>49</td>
<td>&lt;.001</td>
<td>[1.00, 3.32]</td>
</tr>
<tr>
<td>CS+ vs. GS6</td>
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<td>49</td>
<td>&lt;.001</td>
<td>[1.14, 3.62]</td>
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<tr>
<td>US-expectancy – Generalization Block 2</td>
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<td>CS+ vs. CS-</td>
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<td>[0.06, 1.59]</td>
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<td>CS+ vs. GS2</td>
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<tr>
<td>CS+ vs. CS-</td>
<td>2.82</td>
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<td>[0.44, 2.64]</td>
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<td>CS+ vs. DS</td>
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<td>[0.46, 2.34]</td>
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<td>49</td>
<td>.44</td>
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<td>CS+ vs. GS2</td>
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<td>CS+ vs. GS4</td>
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<td>49</td>
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<td>CS+ vs. GS5</td>
<td>2.73</td>
<td>49</td>
<td>&lt;.01</td>
<td>[0.37, 2.43]</td>
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<tr>
<td>CS+ vs. GS6</td>
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<td>49</td>
<td>&lt;.05</td>
<td>[0.18, 2.46]</td>
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<tr>
<td>Fear of pain – Generalization Block 2</td>
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<td></td>
<td></td>
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<tr>
<td>CS+ vs. CS-</td>
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<td>49</td>
<td>&lt;.01</td>
<td>[0.72, 2.76]</td>
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<td>[0.63, 2.61]</td>
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<td>CS+ vs. GS1</td>
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<td>&lt;.05</td>
<td>[0.19, 1.54]</td>
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<td>CS+ vs. GS2</td>
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<td>.35</td>
<td>[-0.50, 1.38]</td>
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<td>CS+ vs. GS3</td>
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<td>49</td>
<td>&lt;.01</td>
<td>[0.63, 2.61]</td>
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<td>[0.68, 2.68]</td>
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<tr>
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<td>49</td>
<td>&lt;.01</td>
<td>[0.76, 2.83]</td>
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<tr>
<td>CS+ vs. GS6</td>
<td>3.14</td>
<td>49</td>
<td>&lt;.01</td>
<td>[0.59, 2.69]</td>
</tr>
</tbody>
</table>
A. Anticipatory fear of pain during acquisition and extinction

B. Anticipatory fear of pain during generalization

FIGURE 4  Mean anticipatory pain-related fear ratings, A, for the CS+, CS- and distractor stimuli (DSs) separately during the three acquisition blocks (a1-3), and B, for the CS+ , CS-, the DSs and the six generalization stimuli (GS1-6) separately during both the generalization blocks (g1-2). Vertical bars denote standard errors.
second generalization block (g2), $F(1, 49) = 13.42, p < .001$. The generalization gradient was further supported by multiple planned comparisons (see Table 1). These comparisons revealed that during both generalization blocks, the difference in fear-related fear between the CS+ and CS- remained significant, g1: $t(49) = 2.82, p < .01$, 95% CI [0.44, 2.64]; g2: $t(49) = 3.41, p < .01$, 95% CI [0.72, 2.76], as well as the difference in pain-related fear reported between the CS+ and DS, g1: $t(49) = 2.99, p < .01$, 95% CI [0.46, 2.34]; g2: $t(49) = 3.30, p < .01$, 95% CI [0.63, 2.61]. Again, no such differences were observed between the CS- and the DS in either of the generalization blocks, g1: $t(49) = -0.66 , p = .51$, 95% CI [-0.57, 0.29]; g2: $t(49) = -0.63, p = .53$, 95% CI [-0.50, 0.26]. Furthermore, during the first generalization block, the pain-related fear in response to the GS1 did not differ from the CS+, $t(49) = 0.78, p = .44$, 95% CI [-0.28, 0.64]. There was also no significant difference in fear reported to the GS2, $t(49) = 1.29, p = .20$, 95% CI [-0.24, 1.12], and the GS3, $t(49) = 1.69, p = .10$, 95% CI [-0.15, 1.75], as compared with the CS+. During the generalization second block, contrary to our expectations, there was a significant difference in pain-related fear triggered by the CS+ and GS1, $t(49) = 2.59, p < .05$, 95% CI [0.19, 1.54] but the difference between the pain-related fear elicited by the CS+ and the GS2 did not differ, $t(49) = 0.94, p = .35$, 95% CI [-0.50, 1.38].

**Extinction effects.** We performed a $3 \times 3$ [Stimulus Type (CS+/CS-/DS) × Block (e1-3)] RM ANOVA on the pain-related fear ratings for the different hand postures, averaged per extinction block (see Figure 4, panel A). There was a significant main effect of stimulus type, $F(2, 98) = 14.34, p < .001, \bar{\varepsilon} = .55, \eta^2_p = .23$, and a significant main effect of block, $F(2, 98) = 45.82, p < .001, \bar{\varepsilon} = .86, \eta^2_p = .48$, indicating that US-expectancy ratings differed depending on stimulus type and decreased across blocks. The crucial Stimulus Type × Block interaction was significant, $F(4, 196) = 3.09, p = .048, \bar{\varepsilon} = .52, \eta^2_p = .06$, suggesting that the pain-related fear ratings for both CSs developed differently during the extinction phase. Furthermore, there was a significant decline in the differences fear elicited by the CS+ and CS- from the beginning of the extinction phase compared with the end of the extinction phase, $F(1, 49) = 4.19, p < .05$. Planned comparisons revealed that at the beginning of the extinction phase (e1), (a) participants were still more afraid of the CS+ hand postures than of the CS- hand postures, $t(49) = -3.87 , p < .001, 95\%$ CI [0.80, 2.52], (b) they reported more fear of pain for the CS+ hand postures than for the DS hand postures, $t(49) = 3.58, p < .001, 95\%$ CI [-2.38, -0.67], and (c) there were no significant differences in pain-related fear ratings between the CS- and the DS, $t(49) = -1.05, p = .30, 95\%$ CI [-0.12, 0.39]. Planned comparisons at the end of the extinction phase (e3) further showed that (a) contrary to our expectations, participants were still more afraid of the CS+ hand postures than of the CS- hand postures, $t(49) = -2.79, p < .01, 95\%$ CI [0.25, 1.51], (b) they reported more pain-related fear in response to the CS+ hand postures than in response to the DS hand postures, $t(49) = 3.21, p < .01, 95\%$ CI [-1.30, -0.30], and (c) there were no significant differences in fear of pain ratings between the CS- and the DS, $t(49) = -0.68, p = .50, 95\%$ CI [-0.16, 0.32].

**Eyeblink Startle Modulation**

**Acquisition effects.** We analyzed the mean startle responses during acquisition using a $3 \times 4$ [Block (a1-3) × Stimulus Type (CS+/CS-/DS/ITI)] RM ANOVA (see Figure 5). The analysis comparing psychophysiological fear responding elicited during the mental rotation of the different hand postures and the ITI revealed significant main effects for stimulus type, $F(3, 147) = 14.65, p < .001, \bar{\varepsilon} = .63, \eta^2_p = .23$, and for block, $F(2, 98) = 37.90, p < .001, \bar{\varepsilon} = .78, \eta^2_p = .44$, indicating habituation—that is, startle responses declined gradually across blocks. As expected, there was a significant Stimulus Type × Block interaction, $F(6, 294) = 3.72, p < .01, \bar{\varepsilon} = .83, \eta^2_p = .07$. In contrast with our predictions, planned comparisons did not reveal the expected difference between startle responses elicited during the mental rotation of the CS+ hand postures and those elicited during mental rotation of the CS- hand postures, $F < 1$. Based on the visual inspection of Figure 5, we conducted a *post-hoc* comparison trying to capture what was driving the interaction effect. Throughout the acquisition phase, startle responses elicited during the ITI were elevated as compared to the startle responses elicited during motor imagery (irrespective of the specific stimulus type: CS+, CS- or DS), $F(1, 49) = 21.40, p < .001$.

**Generalization effects and extinction effects.** Because there were no reliable acquisition effects in the startle eyblink measures, generalization and extinction effects will not be further reported.

**Response Latency**

Twenty-four of the 50 participants failed to give a left-right judgment within 5,000 ms at least once during the experiment (in total 152 trials). In total, 134/7,600 trials were no-response trials, which corresponds with 1.8% of the total trial set. Of these 134 no-response trials, 18 were CS- trials
(±13%), 16 CS+ trials (±12%), 66 DS trials — including 4 different DSs and thus corresponding with ±16% per DS type— (±49%), 6 GS1-2-4-5-6 trials (±4.5% per GS type, ±23% in total), and 4 GS3 trials (±3%). Six of the 50 participants gave a left-right judgment quicker than 500 ms after the picture onset at least once during the entire experimental task (in total 152 trials). In total 23/7,600 trials were premature response trials, which corresponds with 0.3% of the total trial set. Of these 23 trials, 8 were CS- trials (±35%), 6 CS+ trials (±26%), 7 DS trials (±30%), and 2 GS2 trials (±9%).

**Acquisition effects.** We analyzed the mean response latency during acquisition using a 3 × 3 [Block (a1-3) × Stimulus Type (CS+/CS-/DS)] RM ANOVA (see Figure 6). The analysis comparing response latencies of the laterality judgments for the different type of hand postures showed a significant main effect for block, F(2, 98) = 5.99, p < .01, ε = .87, η² = .11, but no significant main effect for stimulus type, F(2, 98) = 3.19, p = .06, ε = .84. The anticipated Stimulus Type × Block interaction was also not significant, F < 1. Notwithstanding the absence of a significant interaction, we continued to test our *a priori* hypothesis. Planned comparisons did not confirm our hypothesis that participants would be quicker to judge the laterality of the hand postures that predicted the painful outcome (CS+) than the one that was not predicting the pain-US (CS-), F < 1.

**Generalization and extinction effects.** Because there were no reliable acquisition effects in the response latency measure, generalization and extinction effects will not be further reported.

**Discussion**

Previous research showed that fear of movement-related pain emerges after repeated pairings of a neutral joystick movement (CS+) with pain (Meulders et al., 2011) and that fear generalizes selectively to novel joystick movements that resemble the original CS+ movement, but not to those that resemble the original CS- movement (Meulders, Vandevoort, Vervliet, & Vlaeyen, 2013; Meulders & Vlaeyen, 2013a). Finally, fear of movement-related pain can subsequently be reduced using a Pavlovian extinction procedure (Meulders & Vlaeyen, 2012). Interestingly, it has been demonstrated that even the mere intention to perform a painful movement can function as a covert conditioned stimulus and can start to elicit pain-related fear and that this fear can
subsequently be reduced through Pavlovian extinction (Meulders & Vlaeyen, 2013b). Based on these previous findings and the well-documented observation that motor intention and motor imagery are closely related, it can be argued that even without motor intention or preparation, imagining a painful movement, might similarly evoke pain-related fear. First of all, the verbal ratings showed that participants expected the pain-US to occur more after the CS+ hand posture than after the CS- hand posture. In addition, they also reported being more afraid of the CS+ hand posture than the CS- hand posture. These results indeed seem to suggest that pain-related fear can be acquired in response to the hand postures presented in different orientations. Further, we successfully demonstrated a generalization gradient in both verbal ratings. More specifically, there was a linear decrease in US-expectancy and self-reported pain-related fear for the novel generalization hand postures (GSs) approaching the original CS-, with novel hand postures more similar to the original CS+ eliciting more pain-related fear and US-expectancy than those more similar to the CS-. Finally, we also found successful extinction of pain-related fear in both verbal measures. That is, the difference in US-expectancy and pain-related fear ratings between the CS+ hand posture and the CS- hand posture significantly decreased during extinction. However, at the end of the extinction phase, participants still expected the pain-US to occur more and reported more fear of the CS+ hand posture than of the CS- hand posture. These results seem to suggest that pain-related fear, triggered by hand postures presented in different orientations, was significantly reduced, but not fully extinguished.

Second, we did not observe acquisition of pain-related fear during motor imagery of hand postures in the startle eyeblink measures. These results were unexpected and are clearly dissociated from the findings in the verbal measures. In contrast with our expectations, we observed elevated startle eyeblink responses elicited by probes during the ITI (i.e. context alone) as compared with the responses during mental imagery irrespective of the stimulus type. These results seem to suggest that instead of affective startle potentiation (Vrana, Spence, & Lang, 1988), our procedure produced startle inhibition. Previous research on affective modulation of the

![FIGURE 6](Image) Mean response latency for the laterality judgments for the respective hand pictures (CS+, CS- and DS) separately during the acquisition phase (a1-3) and the extinction phase (e1-3). Vertical bars denote standard errors.
startle eyeblink response suggests that an acoustic startle probe, presented at 500 ms after the picture presentation, as we did here, should not generate inhibition but facilitation of the startle response (Bradley, Codispoti, & Lang, 2006). However, attentional processes and cognitive load have been shown to affect affective startle modulation as well (Acocella & Blumenthal, 1990; Filion, Dawson, & Schell, 1993; Schell, Wynn, Dawson, Sinaii, & Niebala, 2000). As such, it is possible that the cognitive load of the left-right HJT (i.e., participants were mentally rotating their hand into the displayed hand postures) interfered with the startle modulation and produced inhibition of the startle response. The observation that the startle responses during the context alone (ITI) were consistently larger than those occurring during mental imagery of all hand postures is consistent with this possibility. Because of the lack of effect in the startle measures, we cannot draw firm conclusions about whether the “imagined movements” (i.e., motor imagery of the hand postures) gained associative strength rather than the hand posture pictures themselves.

Third, we did not observe any differences in reaction times to give laterality judgments for the CS+ hand posture as compared with the CS- hand posture. A recent meta-analysis on attentional bias towards pain-related information revealed an attentional bias of medium effect size \(d = 0.676\) (Crombez, Van Ryckeghem, Eccleston, & Van Damme, 2013) towards signals of impending experimental pain in healthy volunteers. The present results do not corroborate those findings. One possible explanation for the absence of the attentional bias is that left-right judgments typically consist of different processes (initial judgment, mental imagery, and decision making) that sum up to the total response latency. Therefore, even if the initial identification of the CS+ hand picture was facilitated, but no differences occur during mental imagery and decision making, the attentional threat bias might still not be picked up by assessing the complete reaction time of the laterality judgment. Of further relevance to this issue is a previous finding that experimentally induced pain in one hand (Moseley, Sim, Henry, & Souvlis, 2005) and experimentally induced expectation of pain in one hand are associated with a longer response latency for left-right judgments of the other hand (Hudson, McCormick, Zalucki, & Moseley, 2006). This is the opposite pattern to that observed in people with complex regional pain syndrome, who take longer to make the left-right judgments when the picture corresponds with their painful hand (Moseley, 2004a, 2004c, 2005). These opposing patterns of delay have been attributed to an information processing bias associated with ambiguous stimuli, such that the bias triggers an erroneous first decision, which is not confirmed by the motor imagery and a second decision is made, which is then confirmed. Thus, although there is a side-to-side delay, it reflects not a slowing down of CNS processing, but an interpretation bias manifesting in the first stage of the left-right judgment task. It may be then, that, in the present study, the CS+ and CS- pictures were sufficiently different to avoid such an interpretation bias and, thus, there was no delay.

Some interesting findings deserve further attention. First, it should be noted that the acquisition training itself can be interpreted as a type of generalization learning, because the CS+ consisted of the same hand posture presented in four orientations. As mentioned before, this procedure was applied to induce motor imagery that is required to perform the task (Decety et al., 1994; Gerardin et al., 2000; Parsons et al., 1995; Stephan et al., 1995). As a consequence, participants had to integrate this information and generalize this knowledge across the four orientations of each stimulus type. Therefore, it is unlikely that the visual image, per se, was conditioned to elicit pain-related fear because the four orientations provide distinct visual images that are difficult to match without performing the left-right task. Therefore, it is possible that even though participants engaged in motor imagery, the “imagined movements” themselves did not become conditioned stimuli, but that participants simply identified the end point hand posture as the predictor of the painful stimulus. Second, using several orientations offers a likely explanation for the incomplete extinction. It is possible that generalization of inhibitory learning (during extinction) from one orientation to another orientation is more difficult than generalizing the excitatory learning (during acquisition). Closely related is the well-known dissociation between first and second learned associations: acquisition learning (first learned association) normally generalizes easily, whereas extinction learning (second learned association that inhibits the behavioral expression of the first learned association) does not, although it is more context-dependent (Bouton, 1984, 1988, 1994, 2002).

Interpretation of the current study results should consider some limitations. First of all, there was no explicit measure to confirm that participants actually engaged in motor imagery to generate the left-right hand judgments. We only measured response accuracy as an implicit measure of motor imagery, that is, participants in general gave more correct left-right judgments than expected at chance level, suggesting that they most likely did mentally rotate their own hand in the displayed hand
postures. Future research might include more explicit manipulation checks. Second, because our startle measures did not replicate the findings observed in the verbal ratings, we cannot firmly conclude that the US-expectancy and pain-related fear ratings relate to the motor imagery of the hand postures rather than the visual aspects of the displayed hand postures (unrelated to imagined movements). As a consequence it should be concluded that the present paradigm is not suitable to study conditioning of pain-related fear of imagined movements with startle eyeblink measures as a main outcome. Future research might register event-related potentials (ERP) as a central index of fear perception during motor imagery (Williams et al., 2004). The recording of ERP s indeed can provide millisecond resolution of the perceptual and decision-making processes that follow stimulus onset (Lim et al., 1999; Ugland, Dyson, & Field, 2013). In general, previous research has shown that early neural responses (P1, N1 [Wong, Bernat, Bunce, & Shevrin, 1997] and P2 [Wong, Bernat, Snodgrass, & Shevrin, 2004]) may all index aspects of fear conditioning. Larger amplitudes appear to be broadly characteristic of the CS+ relative to the CS− and these effects appear to be robust for later components related to discrimination (N1 and P2) relative to an earlier P1 component that is often associated with physical stimulus features, attention and arousal (Olofsson, Nordin, Sequeira, & Polich, 2008). Because these ERP components emerge in less than 500 ms after stimulus onset, a setup including such ERP measures might be more sensitive to pick up differences between the CS+ and CS- in the further study of pain-related fear of imagined movements.

To conclude, we showed that (a) a painful hand posture triggers fear and increased US-expectancy as compared to a nonpainful hand posture, (b) this pain-related fear spreads to similar but distinct hand postures following a generalization gradient, and subsequently, (c) it can be reduced using an extinction procedure. These effects were apparent in the verbal ratings, but not in the startle measures. Additionally, we failed to observe an attentional threat bias towards the painful hand postures in the response latency of the laterality judgments.

Conflict of Interest Statement
The authors declare that there are no conflicts of interest.

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