



Empathy hurts: Compassion for another increases both sensory and affective components of pain perception

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Abstract

Recent studies demonstrate that some brain structures activated by pain are also engaged when an individual observes someone else in pain, and that these empathy-related responses are modulated as a function of the affective link between the empath and the individual in pain. In this study we test the hypothesis that empathy-evoked activation in the pain network leads to heightened pain perception. After inducing in half of our subjects a state of high empathy for an actor and in the other half a state of low empathy towards him, we measured the sensitivity to heat stimuli of various intensities in healthy participants while they watched the actor being exposed to similar stimuli. Participants in the “high-empathy” group rated painful (but not non-painful) stimuli applied to themselves as more intense and unpleasant than did those in the “low-empathy” group. Positive correlations between state empathy scores and pain ratings further suggest that this perceptual phenomenon depends on the magnitude of empathic response induced in the participants. The effects were observed when subjects watched the model receiving either neutral or painful stimuli, suggesting that it is empathy itself that alters pain perception, and not necessarily the observation of pain behaviors.

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1. Introduction

Empathy is a complex psychological construct characterized by a sense of knowing, and even sharing, the experience of another person. Both bottom-up (e.g., the observation of pain behaviors) and top-down (e.g., the affective link between the empath and the person in pain) processes shape the cognitive, affective

and behavioral responses accompanying this phenomenon (Goubert et al., 2005; Decety and Lamm, 2006). Studies of the neural bases of empathy for pain using functional magnetic resonance imaging (fMRI) and transcranial magnetic stimulation (TMS) (see de Vignemont and Singer, 2006) suggest that the subjective experience of ‘feeling another’s pain’ is mediated by some of the same brain structures involved in processing painful stimuli to the self. Several fMRI studies (Singer et al., 2004; Morrison et al., 2004; Jackson et al., 2005; Botvinick et al., 2005; Singer et al., 2006; Saarela et al., 2007) have demonstrated that exposure to somebody in pain elicits increased activity

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in the anterior cingulate and fronto-insular cortices, structures which are thought to encode the affective component of pain (Rainville et al., 1997; Peyron et al., 2000; Craig, 2002; Critchley et al., 2004). Consistent with these results, one study reported a neuron in the human anterior cingulate cortex that fired during both the perception and the mere observation of pain (Hutchison et al., 1999). Although none of these studies reported significant empathy-related activity in the primary somatosensory cortex, two experiments using TMS and one using somatosensory evoked potentials (SEPs) suggest that the observation of others in pain may affect this cortical area as well (Avenanti et al., 2005, 2006; Bufalari et al., 2007).

In light of the growing literature indicating that empathy is associated with the vicarious activation of the pain system, we predicted that empathic states would induce sensitization of cortical areas involved in the processing of noxious stimuli, resulting in increased pain sensitivity. In support of this hypothesis is the recent report that laboratory mice have heightened pain behavior when exposed to cagemates, but not to strangers, in pain (Langford et al., 2006). Several human studies also showed that the exposure to an actor in pain (Craig and Weiss, 1971; Craig et al., 1975), or even the simple observation of pictures of human pain (Godinho et al., 2006) is associated with higher pain reports. However, by having changed the content of pain cues across conditions, none of these studies has separated the effects of empathy from those of other factors such as social modeling (Craig and Weiss, 1971; Craig et al., 1975), conditioned affective responses and/or mood alterations (Villemure et al., 2003; Rainville et al., 2005). Given that the observation of pain is not necessary to evoke empathy, we further predicted that pain sensitivity would be altered by empathy manipulations not involving the direct observation of pain. To evaluate the effects of empathy on pain perception, we measured subjects' sensitivity to painful and non-painful heat stimuli while they watched an actor experiencing painful or non-painful stimuli, after differentially manipulating the affective link between the subjects and the actor.

2. Materials and methods

2.1. Subjects and actor

Exclusion criteria for the experiment included pregnancy or breastfeeding, current use of analgesic drugs, and serious cardiovascular or neurological diseases. Furthermore, participants were excluded from data analysis ($n = 12$) if during post-experimental interviews they expressed doubts about the credibility of the actor (see below), a 23 year-old male, at the time employed as a research assistant in our laboratory. Based upon these criteria, 24 men and 24 women, from 18 to 31 years old, were included in the final analysis (Table 1). Ethical approval was obtained through the Institutional Review Board of the Faculty of Medicine of McGill University.

2.2. Testing paradigm

Fig. 1 shows a schematic representation of the testing sequence. Participants' sensitivity to thermal stimuli was tested twice. In both occasions, the same series of 16 non-painful (42 and 44 °C) or painful (46.5 and 48 °C) thermal stimuli was delivered on the back of the participants' left hand through a 30 × 30-mm contact thermode (TSA II Neuro-Sensory analyzer, Medoc Ltd., Advanced Medical System, Israel). Each stimulus lasted six seconds (1 s to reach the target temperature, 4 s at plateau, and 1 s to return to the baseline temperature of 32 °C). In the first session ('baseline' testing session), stimuli were presented while the subjects watched an 8-min 'neutral' cityscape video (Supplementary Movie 1 online); this video was selected for its emotional neutrality on the basis of the judgments of 15 subjects who participated in a preliminary experiment (average pleasantness/unpleasantness rating: 0.6 ± 2.2 on a scale anchored with $-10 =$ 'extremely unpleasant' and $+10 =$ 'extremely pleasant', with a mid-point of $0 =$ 'neutral'). After the baseline session, depending on the experimental group, participants watched either a video interview designed to evoke compassion, in which the actor told a sad personal story ('Positive Affective Link', or 'AFF+' group) (Supplementary Movie 2 online), or another interview in which the same actor told a personal story aimed at eliciting a state of low empathy towards him ('Negative Affective Link', or 'AFF-' group) (Supplementary Movie 3 online). Both interviews were specifically designed to induce a negative mood state, but with only one inducing empathy. Given the importance that the fictitious interviews be credi-

Table 1
Breakdown table of descriptive statistics relative to sex composition, age and dispositional empathy

| Group | Sex | Age | BEES | IRI | | | | N |
|-------|-----|------------|------------|------------|------------|------------|------------|----|
| | | | | FS | EC | PD | PT | |
| AFF+ | F | 22.9 ± 0.9 | 49.8 ± 6.4 | 18.8 ± 1.5 | 22.3 ± 1.1 | 11.9 ± 2.0 | 16.9 ± 1.6 | 12 |
| | M | 23.6 ± 1.0 | 48.7 ± 7.8 | 18.6 ± 2.3 | 20.0 ± 1.1 | 11.9 ± 1.6 | 18.0 ± 1.8 | 12 |
| AFF- | F | 23.5 ± 1.3 | 58.3 ± 7.5 | 19.3 ± 1.3 | 22.2 ± 1.1 | 13.8 ± 1.3 | 19.8 ± 1.3 | 12 |
| | M | 21.4 ± 0.9 | 44.8 ± 7.9 | 19.9 ± 1.2 | 20.0 ± 1.2 | 11.9 ± 1.1 | 19.9 ± 1.2 | 12 |
| TOTAL | | 22.9 ± 0.5 | 50.4 ± 3.7 | 19.1 ± 0.8 | 21.1 ± 0.6 | 12.4 ± 0.8 | 18.6 ± 0.7 | 48 |

BEES, Balanced Emotional Empathy Scale; IRI, Interpersonal Reactivity Index; FS, Fantasy; EC, Empathic Concern; PD, Personal Distress; PT, Perspective Taking. The mean ± SEM are shown.

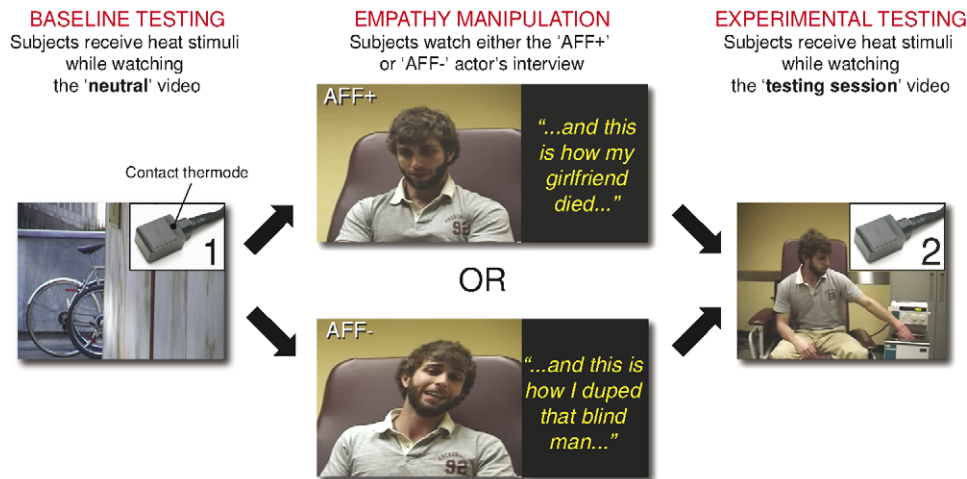


Fig. 1. Schematic representation of the study design. First, participants' sensitivity to non-painful and painful stimuli was measured during the exposure to a neutral cityscape video. Next, the participants were asked to give a brief video interview, on a topic chosen from a list provided (not shown). The actor's interview was then shown (after introducing the actor as another study participant), followed by the second thermal testing session (which was performed while participants watched the 'testing video'). Finally, post-experimental questionnaires were presented to the participants. After both testing sessions, as well as after the actor's and the subject's interviews, participants also rated their mood and level of stress.

ble, the participants were told that the actor was another participant in the study, and that giving a brief interview was part of the experiment. To reinforce the subjects' beliefs, participants themselves were asked to tell a brief story in front of a camera, choosing a topic from those provided in a list. Then, both groups participated in a second psychophysical testing session ('experimental' testing session), in which their sensitivity to the same sequence of non-painful and painful heat stimuli previously used was tested while they watched another 8-min video ('testing video', [Supplementary Movie 4 online](#)); this video included alternating 2-min segments showing the actor receiving non-painful and painful thermal stimuli ('no-pain' and 'pain' videos), each repeated twice in a counterbalanced order.

Before each session, all subjects were instructed to pay attention to both the videos and the heat stimuli delivered to their hand, and that they would be required to answer questions about the video and rate the pain. Attentional demands were therefore kept constant across groups.

2.3. Visual Analogue Scales

Subjects were instructed to rate the intensity and hedonics (pleasantness/unpleasantness) of each thermal stimulus immediately after its presentation, and to quickly redirect their attention to the video once the ratings were expressed. Ratings were expressed verbally, while observing modified Visual Analogue Scales (Fig. 2) as a reference. We chose not to interrupt the video during the rating periods in order to minimize the disruption of the subjects' empathetic state. At the conclusion of both testing sessions, as well as after the actor's and the subject's own interviews, participants also rated their mood and level of stress, using visual analogue scales similar to those previously employed in our laboratory (Villemure et al., 2003). At the end of the 'experimental' session, subjects also estimated how much pain they thought the actor was experiencing, using visual analogue scales.

2.4. State and trait empathy questionnaires

We measured both 'state' and 'trait' empathy in each subject. Whereas 'trait empathy' refers to the dispositional tendency to respond empathically to every-day life situations, 'state empathy' describes the empathic concern evoked in the here-and-now (in this case, to the interview and the pain video). State empathy was measured after the 'experimental' session, using a five-item questionnaire which has previously been shown to be a reliable measure of state empathic concern (Oswald, 1996). At the end of the study, participants were asked to complete two commonly used trait empathy questionnaires: the Interpersonal Reactivity Index (IRI; Davis, 1980), which includes the four subscales Fantasy (FS), Empathic Concern (EC), Personal Distress (PD) and Perspective Taking (PT) and the Balanced Emotional Empathy Scale (BEES; Mehrabian, 2000).

2.5. Statistical analysis

Ratings of stimulus intensity and unpleasantness taken during baseline and experimental testing periods were compared between groups using the General Linear Model (GLM), including the factors Group ('AFF+' vs. 'AFF-') and Sex. In addition, a series of single-sample *t*-tests were performed on the baseline intensity ratings against the value of 100 ('pain threshold'), to determine whether each temperature was rated as painful or not. A similar analysis was performed on the pleasantness/unpleasantness ratings (against the reference value of 0 = 'neutral'). A GLM analysis was also performed on ratings of mood and stress, using the factors of Group and Sex, and on the 'pain in the actor' estimates and state empathy ratings, using the factors of Group, Sex and Video ('pain video' vs. 'no-pain video'). In order to evaluate the effect of the empathic manipulation on the intensity and unpleasantness ratings of heat stimuli, two change scores per temperature were computed for each subject: (1) the average rating recorded

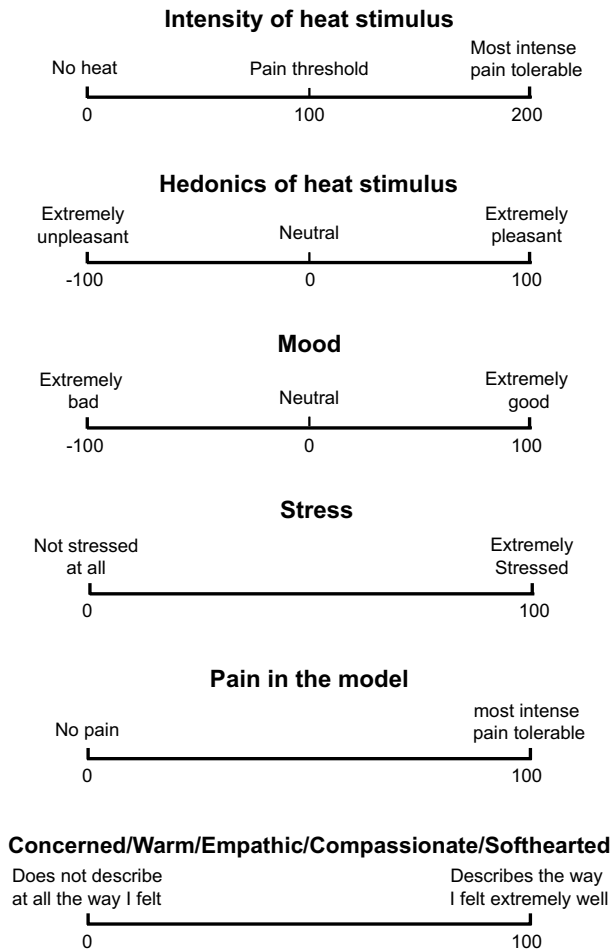


Fig. 2. Visual Analogue Scales used during the experiment. After each heat stimulus, subjects were asked to numerically rate its intensity and hedonics (pleasantness/unpleasantness). After the ‘baseline’ and ‘testing’ sessions, as well as after the actor’s and the subject’s own interviews, participants also rated their mood and their stress level. Finally, after the ‘experimental’ session participants also estimated the actor’s pain, and rated their empathy towards him. The actor was presented to the participants as another participant of the experiment, and referred to as the ‘model’ throughout the experiment.

during the pain video minus the baseline rating recorded during the neutral video; (2) the average rating recorded during the no-pain video minus the baseline rating recorded during the neutral video. The GLM was used to evaluate the effect of the factors Group, Sex, and Video, on these intensity and unpleasantness ‘change scores’ (with 42, 44, 46.5 and 48 °C as the four levels of the ‘Temperature’ within-subjects variable). Since no significant main effects or interactions of Sex were observed in these analyses, these will not be discussed further. Given that mood changes affect pain perception (Villemure et al., 2003), the differences between the mood scores collected after the actor’s interview and those collected during the first testing session were used as a covariate in our analysis, in order to statistically remove the effect of this factor. Since 48 °C was the only temperature that reliably evoked pain in the majority of subjects (>83% in both sessions), we further examined the relationship between these pain ratings and the state empathy

ratings using correlational analyses (Pearson’s r). Although the average rating for 46.5 °C was above pain threshold, less than half the subjects (48% in both sessions) rated this temperature as painful; thus we chose to exclude it from the correlational analysis. Finally, ANOVAs were employed to evaluate the effects of Group and Sex on trait empathy scores. All significant interactions between factors were decomposed using simple main effects analyses. Throughout the text and in the figures, means are presented \pm their relative SEM.

3. Results

3.1. Baseline temperature ratings

Fig. 3 shows that during the observation of the neutral video (baseline), the average ratings of 42 and 44 °C were below pain threshold (p 's < 0.001), and the ratings of 46.5 and 48 °C were above pain threshold (p < 0.05 and p < 0.001, respectively). The AFF+ and AFF– groups did not differ in their ratings of pain intensity or unpleasantness during this baseline testing period preceding the empathy manipulation (Group * Temperature interactions not significant, F 's(3, 138) < 1.14, p 's > 0.05).

3.2. Effectiveness of empathy manipulation

The GLM was used to examine the effects of the factors Group, Sex, and Video on the state empathy ratings. Substantiating the effectiveness of our empathy manipulations, the factor Group had a significant main effect on state empathy ratings, $F(1, 44) = 15.75$, $p < 0.001$, indicating that participants assigned to the AFF+ group reported higher ratings of state empathy towards the actor than those assigned to the AFF– group (Fig. 4a). Despite these differences in state empathy, participants’ estimates of the actor’s pain were not different between groups (48.1 ± 1.2 vs. 47.8 ± 1.2 , $p > 0.05$). ANOVAs (factors: Sex, Group) indicated that the empathic manipulation also affected mood ratings (AFF+ = $\Delta -51.2 \pm 9.4$; AFF– = $\Delta -10.3 \pm 8.2$, $F(1, 44) = 10.69$; $p < 0.01$), but not the self-reported stress ratings (AFF+ = $\Delta 4.9 \pm 6.2$; AFF– = $\Delta -0.6 \pm 3.4$, $F(1, 44) = 0.59$, $p > 0.05$).

3.3. Effect of empathy on temperature ratings

GLM (with mood change scores as covariates) was used to assess the effects of the manipulation of the affective link on the perceived intensity and unpleasantness. While watching videos of the actor, participants in the AFF+ group rated painful stimuli applied to themselves as more intense and unpleasant than did those in the AFF– group (Fig. 4b and c), as demonstrated by a significant Group \times Temperature interaction for intensity, $F(3, 129) = 3.9$, $p = 0.01$, and unpleasantness, $F(3, 129) = 5.5$, $p < 0.01$, ratings. Simple main effects

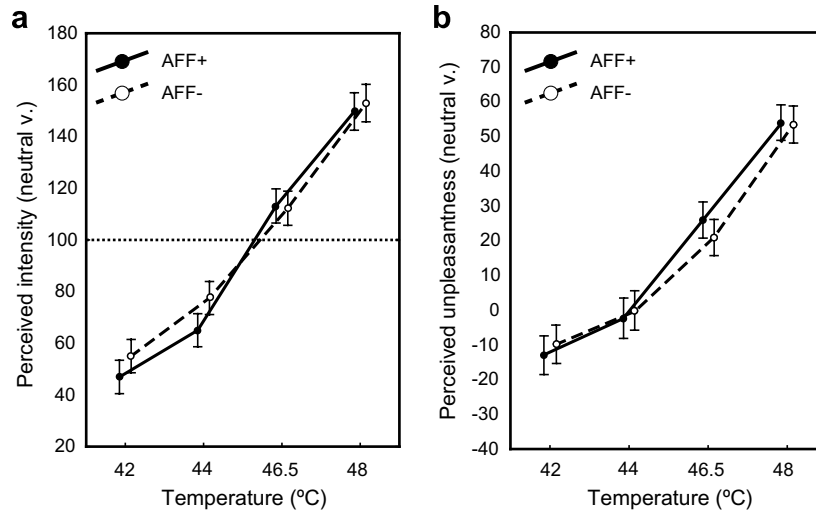


Fig. 3. Baseline absolute ratings of intensity (a) and unpleasantness (b). Participants on the average rated the stimuli at 42 and 44 °C as significantly below the pain threshold (VAS = 100; dotted line), and the stimuli at 46.5 and 48 °C as above the pain threshold (a). Participants rated the stimuli at 42 and 44 °C as neutral, or slightly pleasant (negative numbers correspond to ratings of pleasantness) and the stimuli at 46.5 and 48 °C as unpleasant. The low and high empathy groups did not differ in their ratings of pain intensity or unpleasantness during this baseline testing period that preceded the empathy manipulation (b). Bars represent mean \pm SEM. For clarity, in this figure and in the following ones, we reported unpleasantness values as positive ratings on an unpleasantness scale, instead of negative values on a pleasantness scale.

analyses revealed that AFF+ participants reported the 48 °C stimulus as more intense, $F(1,172) = 5.66$, $p < 0.05$, and unpleasant, $F(1,172) = 10.42$, $p < 0.01$. Moreover, the AFF+ tended to report the 46.5 °C as more intense, $F(1,172) = 3.53$, $p = 0.06$. However, the two groups did not differ in their sensitivity to non-painful thermal stimuli, either in terms of intensity or unpleasantness, F 's (1,172) < 1.55 , p 's > 0.05 .

3.4. Pain observation effect

The GLM analyses on intensity and unpleasantness ratings also revealed a significant Video effect for unpleasantness ratings, $F(1,43) = 4.3$, $p < 0.05$. This finding shows that subjects reported more pain unpleas-

antness when they were watching the actor experience pain than when watching him experience a neutral stimulus. No Video \times Group interactions were observed (p 's > 0.05), indicating that the effect of pain observation on unpleasantness ratings of heat stimuli was not significantly different between the AFF+ and AFF- groups. Moreover the subjects' estimates of the actor's pain (in the 'pain video') correlated with the ratings of the subjects' own pain unpleasantness ($r = 0.38$, $p < 0.01$).

3.5. Effect of empathy separate from pain observation

In order to determine whether watching the actor's pain behavior was necessary to produce this increase in pain perception, we separated the subjects' pain rat-

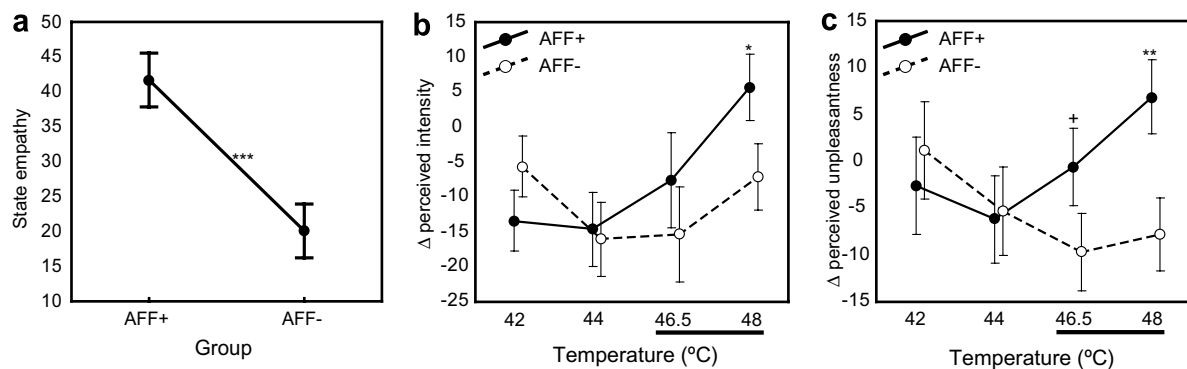


Fig. 4. Effects of empathy on pain perception. Overall, the two groups reported different levels of empathy towards the actor ($p < 0.001$) (a). Empathy increased perceived intensity (b) and unpleasantness (c) of painful but not non-painful stimuli. Simple main effects analyses revealed that high-empathy participants reported the 48 °C stimulus as more intense ($p < 0.05$) and unpleasant ($p < 0.01$), and the 46.5 °C stimulus as almost significantly more unpleasant ($p = 0.06$). Both graphs show the average rating for each temperature while the participants watched the 'testing video' minus the baseline rating recorded while the participants watched the neutral cityscape video. Mood scores were included as covariates in the analyses of the pain ratings. Bars represent mean \pm SEM. $^+p = 0.06$, $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

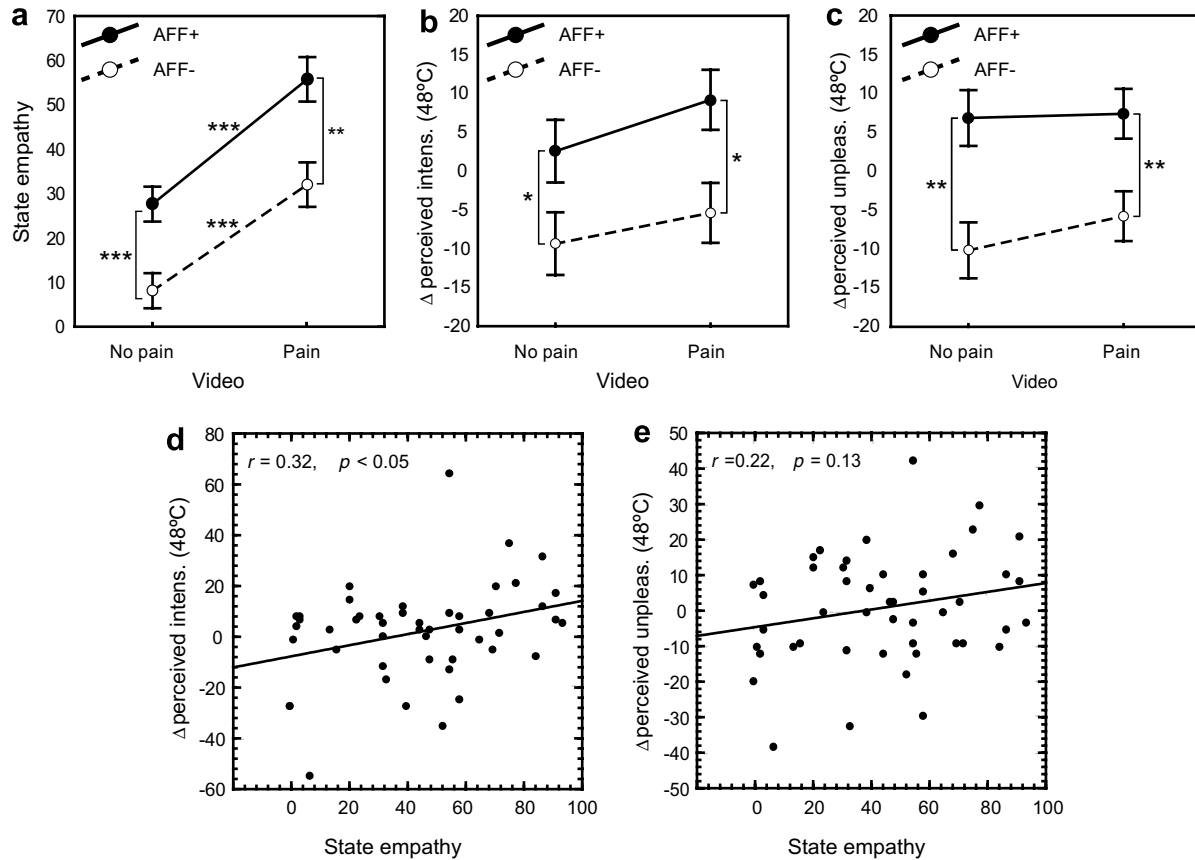


Fig. 5. Pain ratings correlate with empathy ratings. Since 48 °C was the only temperature that reliably evoked pain in the majority of subjects, we examined the relationship between the pain ratings evoked by the 48 °C stimuli and the state empathy ratings. In both pain and no-pain videos, the high-empathy participants reported higher pain ratings than the low-empathy participants (b and c); this paralleled the differences in the state empathy ratings (a). Bars represent mean \pm SEM. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. The state empathy scores elicited by the ‘pain’ video significantly correlated with the intensity ratings (d) and tended to correlate with the unpleasantness ratings (e).

ings obtained while watching the actor in pain from those obtained while watching the actor experiencing a non-painful, warm stimulus. Using the GLM to examine the effects of Group and Video on the intensity and unpleasantness ratings of the 48 °C stimuli, with mood change scores as covariates, we observed that in both the pain and no-pain videos the AFF+ participants reported higher pain ratings than the AFF– subjects (F 's(1, 86) > 6.99, p 's < 0.01 for the unpleasantness ratings in both Pain and No Pain video; F 's(1, 86) > 4.12, p 's < 0.05 for the intensity ratings in both videos; Fig. 5b and c). Correspondingly, state empathy was higher for the AFF+ group than for the AFF– group, whether they were watching the actor experience pain or not (Fig. 5a). To further examine whether a positive affective link between the subjects and actor was itself sufficient to alter participants' pain perception (i.e., that the phenomenon observed did not require the observation of the actor's pain behavior), we separately analyzed trials in which the subjects had not yet seen the actor experiencing pain (i.e., first block of trials in subjects for whom the first video was the no-pain video). Even here we observed a significant Group \times Tempera-

ture effect on the unpleasantness ratings, $F(3, 57) = 4.4$, $p < 0.01$. These observations suggest that empathy itself, and not necessarily the observation of pain behaviors, alters pain perception.

As a further indication that the observed pain modulation depends on the magnitude of empathic response induced in the participants, the state empathy scores elicited by the ‘pain’ video significantly correlated with pain intensity ratings ($r = 0.32$, $p < 0.05$; Fig. 5d). The correlation between state empathy and pain unpleasantness ratings was in the same direction, but did not reach statistical significance ($r = 0.22$, $p = 0.13$; Fig. 5e).

3.6. Trait empathy questionnaires

ANOVAs, with Sex and Group as factors, were performed to compare the scores of the BEES questionnaires and the four subscales of the IRI questionnaire in the two groups. These analyses revealed that the AFF+ and AFF– groups did not differ in terms of dispositional empathy, F 's(1, 44) ≤ 1.74 , p 's > 0.05. None of these scores predicted the magnitude of state empathy induced in the subjects by the actor; moreover, no corre-

lations were observed between pain ratings and trait empathy scores, including trait empathy measures (BEES and the EC subscale of the IRI) which were previously found to significantly correlate with ACC and insular activations (Singer et al., 2004).

4. Discussion

We demonstrate here that the experimental manipulation of empathy towards another can affect pain perception. Participants for whom a state of high empathy (i.e., a positive affective link with another) was evoked rated painful stimuli applied to themselves as more intense and unpleasant than did those for which a state of low empathy (i.e., a negative affective link with another) was evoked. Moreover, the higher the ratings of empathy towards the actor, the higher the participants' own pain ratings. Notably, at the end of the study one of our subjects spontaneously reported that when he was feeling more concerned towards the actor his own pain seemed to increase.

4.1. Previous studies on the effects of pain observation

Although several studies have shown that empathy activates pain-relevant cortical areas (see de Vignemont and Singer, 2006), and others have documented the effects of the observation of pain scenes on pain perception (Craig and Weiss, 1971; Craig et al., 1975; Godinho et al., 2006), remarkably, no study has yet shown that empathy itself increases pain sensitivity in humans. In a number of previous studies, subjects' pain sensitivity was reported to be higher during the observation of pain scenes (e.g., the pain behaviors of an actor, or pictures depicting burns, wounds) than during the observation of other scenes, in which there was less or no pain. Although differences in state empathy could be one explanation for the findings, several other factors could also produce these results. First, witnessing somebody's pain is likely to induce a negative mood state, which has been shown to increase pain perception (Villemure et al., 2003; Rainville et al., 2005). Second, the mere observation of an image implying pain (e.g., a burn) could induce a conditioned autonomic response. Throughout our lives, visual images of our wounds have been paired with the pain caused by them, and thus, through classical conditioning we may experience sympathetic arousal responses to pain images. This increased arousal could itself modulate pain (Rainville et al., 2005). Third, the exposure to the behavior of another individual in pain has been shown to have a significant effect on our own pain behaviors, because it can elicit imitation (Craig and Weiss, 1971; Craig et al., 1975); social modeling could thus partially account for the differences in pain ratings observed in at least some of the aforementioned studies.

4.2. Mood, conditioning, stress and imitation do not explain our results

In our study, possible differences in mood, conditioning, stress and imitative behavior between groups cannot explain the increased pain during a state of high empathy. Since mood is known to affect pain perception (Villemure et al., 2003), mood scores were included as a covariate in the analysis to insure that any differences among subjects would not affect our results. Participants in the two groups were shown exactly the same videos of the actor and rated the actor's pain identically; there was thus no difference in the behavior being modeled or in the conditioning stimulus. Moreover, the AFF+ subjects reported more pain than the AFF– subjects when they watched the model being subjected to a neutral stimulus, further negating an explanation based on conditioning or imitation. Finally, self-reported stress was not different between the two groups, thus excluding this as a possible explanatory factor.

4.3. Could differential attention explain the findings?

When subjects focus attention on a stimulus, they perceive it as more intense. However, the higher pain ratings observed in the AFF+ group of this study are unlikely to result from differences in attentional focus between groups. Attentional modulation of perception is a general phenomenon that applies to pleasant and unpleasant stimuli in all sensory modalities. Pain ratings are higher when an individual focuses on the painful stimulus (Bushnell et al., 1985; Miron et al., 1989; Villemure and Bushnell, 2002; Villemure et al., 2003), but perception of innocuous tactile (Sathian and Burton, 1991), visual (Luck et al., 1994), auditory (Scharf et al., 1987) and taste (Marks and Wheeler, 1998) stimuli are influenced by direction of attention as well. Thus, if the two groups in our study were attending differentially to the stimuli, one would expect the ratings of both non-painful and painful stimuli to be different between groups. This was not the case; only ratings of painful stimuli were affected by our manipulation.

4.4. Does empathy enhance pain or do negative emotions reduce pain?

The group differences observed in our study theoretically could be driven by a reduction of pain sensitivity in the AFF– group, possibly induced by negative feelings, such as anger or disgust, that could have been elicited towards the actor, rather than by differences in empathy between the two groups. However, this explanation is unlikely, since other studies show that induction of negative emotions, such as

anger, lead to an *increase*, rather than a decrease in pain perception (Rainville et al., 2005; Villemure et al., 2003). Moreover, results from these studies consistently indicate that manipulation of the emotional state tends to affect mainly, if not exclusively, the affective component of pain perception, whereas in our study the differences between the two groups are evident in both the affective and sensory dimensions of pain perception. Given that the baseline session always preceded the experimental testing session, the overall reductions of the intensity and unpleasantness ratings observed in the latter (see Figs. 4 and 5) are likely to reflect the effects of habituation and experience with the experimental stimuli.

4.5. Empathy affects pain independently from pain observation

Our findings that subjects in a high-empathy state experience more pain than those in a low-empathy state, independent of the observation of pain behavior in the model, supports the idea that empathy itself, and not necessarily empathy related to the observation of pain behaviors, alters pain perception.

Empathy has been induced in many neuroimaging experiments by exposing subjects to individuals receiving pain. We suggest that the cortical activations observed in these studies (e.g., in the anterior cingulate and insular cortices) may not reflect the specific neural correlates of empathy ‘for pain’ *per se*, but rather activations relating to more general feelings of compassion towards another in distress. According to this view, which is supported by the present psychophysical finding, the mere exposure to others’ emotional distress would lead to the sensitization of areas that are involved in the processing of noxious stimuli. Although the mechanisms underlying this phenomenon still remain to be fully understood, our data are at least partially compatible with the Perception-Action Model (PAM; Preston and de Waal, 2002), which states that empathy for a perceptual or emotional state is mediated by the activation, in the observer’s brain, of the representations of the same state observed. This model would predict that the actor’s perceptual state of physical pain would lead the subjects to automatically activate their own pain areas, possibly explaining why subjects reported more pain unpleasantness when they were watching the actor experience pain than when watching him experience a neutral stimulus. However, it would also predict that the actor’s negative emotional state (i.e., his distress due to recounting the sad personal story in the interview) would lead the subjects to automatically activate brain regions that would be active if they were to experience first-person emotional distress. Since experiencing negative emotional states, such as sadness and

social exclusion, activates similar limbic regions (e.g., anterior cingulate and insula) as does physical pain (Liotti et al., 2000; Eisenberger et al., 2003), the automatic simulation of the actor’s emotional distress (which would be postulated by the PAM) may have therefore led our AFF+ participants to activate their own neural pain mechanisms more than the AFF– participants, resulting in increased pain perception. If this is true, then the true effect of observing the actor in the ‘no pain’ video might simply have been to remind the subject of their empathy towards him. It is noteworthy that we were able to induce these empathy-related changes in pain perception despite the inconsequential nature of the relationship between the participants and the actor (whose only apparent link was to be subjects in a study on pain), the artificial setting in which empathy was elicited (i.e., an aseptic laboratory room) and the type of stimuli delivered to the actor (i.e., a series of thermal stimuli delivered in a fully controlled and ethically regulated experiment, with no life-threatening potential). We predict that in real-life situations where stronger empathic responses are elicited, larger alterations of the observers’ pain perception could occur. In fact, we suggest that empathy may be at least in part responsible for the high frequency of pain symptoms reported by spouses of chronic pain patients (Flor et al., 1987; Leonard and Cano, 2006).

Our results complement the recent report (Langford et al., 2006) that laboratory mice have heightened pain behavior when exposed to cagemates, but not to strangers, in pain and further suggest that empathy mediates this phenomenon. Moreover, by showing that empathy alters both pain intensity and unpleasantness, our results suggest that empathy affects the sensory components of pain processing, and not only the affective components as previously proposed (Singer et al., 2004).

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.pain.2007.07.017](https://doi.org/10.1016/j.pain.2007.07.017).

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