Affective pain modulation in fibromyalgia, somatoform pain disorder, back pain, and healthy controls

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Abstract

Previous research suggested that patients with fibromyalgia (FM) experience a higher pain intensity (clinical pain) than do patients with musculoskeletal pain after negative emotional priming compared to positive priming. To further examine affective pain modulation in FM, we applied an experimental pain induction to compare 30 patients with FM with 30 healthy (pain-free) participants (HC), and 30 patients with back pain (BP). For another group of 30 patients with somatoform pain disorder (SF), we predicted the same pain modulation as for FM. As primes we presented positive, neutral, negative, and pain-related pictures and assessed pain intensity in response to a fixed pressure weight. Overall, picture valence modulated pain intensities (in the order of pain-related > negative pictures > neutral), but the pain intensities between neutral and positive pictures did not differ significantly. SF reported significantly higher pain intensities than did BP and HC; FM were in between, but did not differ significantly from the three other groups. There was no interaction of priming and group. Affective modulation of pain was not specifically altered in FM and SF, but SF were more sensitive to pressure pain than BP and HC.

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Keywords: Fibromyalgia; Somatoform pain disorder; Back pain; Affective pain modulation

1. Introduction

Fibromyalgia (FM) manifests itself through enhanced (pressure) pain sensitivity in patients compared to healthy controls (HC) and patients with other pain disorders (for reviews see Lautenbacher, 1999; Montoya et al., 2005a). The etiology of FM is not completely explained yet. Previous studies have emphasized the role of emotions and psychological stressors in the origin and maintenance of FM, and suggested that pain might be especially prone to the effects of negative mood in FM (Davis et al., 2001; Geisser et al., 2003; Staud et al., 2003; Montoya et al., 2005b).

Montoya et al. (2005b) experimentally induced negative and positive emotional states and assessed pain perception of the current overall pain experienced (i.e., clinical pain) by visual analogue scale in patients with FM and patients with musculoskeletal pain as controls. FM showed an altered affective modulation of pain compared to healthy controls: pain intensity was higher after negative than after positive priming. However, we do not know whether this affective pain modulation in
FM and healthy controls can also be observed using an experimental pain induction method (for a discussion see Geisser et al., 2007). Furthermore, the authors did not induce neutral states so that we do not know either whether the effects they observed on pain are due to a modulation by positive or negative emotions. However, a good number of previous studies examined the influence of experimental mood induction on pain perception in pain-free participants. The finding that positive emotions reduce, whereas negative ones enhance pain intensity, was repeatedly replicated (review in Keefe et al., 2001; Cogan et al., 1987; Zelman et al., 1991; Weisenberg et al., 1998; De Wied and Verbatim, 2001; Meagher et al., 2001; Willoughby et al., 2002; Wunsch et al., 2003; Godhino et al., 2006; Kenntner-Mabiala and Pauli, 2005). Lang’s Motivational Priming Hypothesis (Lang, 1995; Lang et al., 1997) has been used as a plausible theoretical framework to explain the impact of different emotional primes on pain intensity in recent work with emotional picture primes.

Moreover, with respect to negative emotions, it is important, whether the material used for emotion induction contains pain-related cues (De Wied and Verbatim, 2001; Wunsch et al., 2003; Godhino et al., 2006). Although equal in affective quality and arousing pictures with pain-related information evoke higher pain intensities in different pain tests (cold pressor, thermal, or electrical) than negative pictures without direct relevance to pain. In light of this finding it is important to test whether patients with FM experience a higher pain intensity than do HC after priming with pain-related stimuli compared to neutral priming. Also, it is important to know whether the affective pain modulation of back pain patients (BP) who have been reported to be more insensitive to pain than FM and HC (Naliboff et al., 1981; Cohen et al., 1983a; Yang et al., 1985) is similar to the modulation of HC or whether their pain intensity is also enhanced after negative compared to positive primes.

Moreover, the question whether pain-related psychological characteristics have a stronger correlation with pain in FM compared to HC and other pain disorders could provide further evidence for the specificity of pain in FM. A considerable number of prior studies suggested that pain intensity can be predicted by certain pain-related psychological characteristics. Thus, for example catastrophizing and pain-related negative affect predict pain intensity in FM (Staud et al., 2003; Montoya et al., 2005b) and in HC (Sullivan et al., 2004). Similarly, depression and anxiety predict pain intensity in patients with chronic widespread musculoskeletal pain with and without FM (White et al., 2002). Somatization predicts pain in patients with temporomandibular disorder (Sherman et al., 2004), disability in chronic BP (Peters et al., 2005), negative stress coping style in gynaecological patients (Schön et al., 2007), and self-effi-

2. Methods

2.1. Participants

Ninety inpatients with chronic pain were recruited from a specialized rehabilitation clinic for internal medicine, oncology, orthopaedics and psychosomatic medicine. Thirty HC were recruited from the clinic’s
employees in order to have the same experience with the clinic’s setting. Neither patients nor HC were reimbursed for participation. There was no difference in age, gender, marital status and body mass index between patients and HC. The patients had to fulfil the diagnostic criteria for one of the three groups: FM according to the diagnostic criteria of the American College of Rheumatology (ACR), SF according to the criteria of the ICD 10 (F45.4), and BP according to the criteria, disorders of spine and back (ICD 10, M40-M54). Exclusion criteria for the patients were pain duration of less than three months, rheumatic disorders, phantom pain, multiple sclerosis, diabetes mellitus or alcoholism (with polyneuropathy), and myofascial pain syndrome in patients. Exclusion criteria for HC were chronic pain disorders or current mental disorders.

The patient groups were comparable in the average duration of their pain disorder and in the number of non-defining pain problems (occasional headache, inflammation or arteriosclerosis of the upper or lower extremities). The diagnosis of the disorders was assessed by a physician of the clinic. Besides the ACR criterion of at least 11 of 18 painful tender points (TPs) for FM examining also control points (CPs) lead to more specific FM diagnosis in practice (Lautenschläger et al., 1988). The sites of the 11 extra-articular CPs were forehead, underside of both thumbs, inner side of both underarms, upper and underside of both thighs, and both calves. The CPs are located on the middle part of these body parts’ muscles. In FM at most three painful CPs were accepted and in SF there had to be more than three CPs, but the number of TPs was not specified in this group. TPs and CPs were also examined in BP and HC to have the reference of lower and normal pressure sensitivity at these points in relation to FM and SF. Besides the number of points also their pain intensity on the TP or CP the experimenter could control the pressure weight with a digital display. The differences in the number of TPs and CPs between the groups were as expected, with more TPs in FM and SF; SF had the most CPs.

Furthermore, the pain groups were matched according to depression because of the high comorbidity of chronic pain and depression, especially in FM (Meyer-Lindenberg and Gallhofer, 1998). The cut-off-score was 23 in the German version of the Center for Epidemiological Studies Depression Scale (ADS-L) according to Hautzinger and Bailer (1993). The patient groups were thus comparable in the number of depressed patients per group (2 men and 7 women) and in the total number of other psychological disorders (like depression, anxiety, neurasthenia, personality disorders or combination of some of these disorders). Yet, differences were found in the use of pain medication, with a higher number of patients in FM and SF who regularly used pain medication. Also, patients with FM consumed significantly more antidepressants than did patients with BP. Furthermore, there was a difference in education with a higher number of participants in HC compared to BP having more than 9 years of education. The study-relevant clinical and sociodemographic characteristics of the four groups are listed in Table 1 (interval data were analyzed with one-way ANOVAs and nominal comparisons with a chi-square-test).

2.2. Emotion induction

In a complete within-subject design participants were shown seven positive, seven negative, seven pain-related and seven neutral pictures from the IAPS (Lang et al., 1995) on a 19" computer screen.1 Four pictures (one for each category) served as examples in a practice trial. The stimulus presentation was controlled with the software Experimental Run Time System 3.32 (Beri Soft Cooperation, Frankfurt, Germany). The four picture categories were presented as 24 permuted series, the presentation of series was randomized across participants. Within each category the pictures were also randomized. For a manipulation check we assessed the Self- Assessment Manikin (SAM) by Bradley and Lang (1994). The SAM consists of two sets of five cartoon pictographs depicting different levels of affective valence and arousal. For each dimension participants were instructed to place an “X” on or between the figures that best described their experience of the slide category. This yielded ratings ranging from 1 to 9 for each dimension. To assess the intensity of pain relatedness we added a numerical scale ranging from 1 (no pain relatedness) to 9 (high pain relatedness).

2.3. Pain induction and assessment of pain intensity

Pain was elicited by an electronically driven device developed according to Ellermeier and Westphal (1995). By button press of the experimenter a lever with a flat-tipped stylus with a diameter of 3 mm was placed on the dorsal side of the middle phalanx of the index finger during the practice trial and alternately on the middle and the ring finger during the four experimental

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1 The IAPS slide numbers were: practice pictures: 2840, 3064, 8540, 9911; positive: 8170, 8370, 5260, 5621, 8161, 4680, 8030; neutral: 5120, 9360, 2200, 5534, 7002, 7031, 7150; negative: 2730, 2800, 6821, 6212, 9600, 9910, 2205; pain-related: 9410, 9253, 3150, 3010, 3261, 3180, 3350.
The positions of the pressure stimulation were alternated and were on the upper and lower parts of the phalanges of the middle and the ring finger to prevent repetition effects. In right-handed participants the left and in left-handed ones the right hand was tested, because people react with a higher pain sensitivity on the contra-lateral body side (Pauli et al., 1999). For the lever force 5.39 N (550 g) was chosen, based on a previous study (Göbel and Westphal, 1987). Pain intensity ratings were assessed with a throttle which could be moved on a scale from 0 (no pain) to 50 (very strong pain). Whenever the throttle was moved to the top of the scale, the stylus was lifted from the subject’s finger.

2.4. Predictor variables

According to the previous studies (Arnstein et al., 2001; White et al., 2002; Staud et al., 2003; Sullivan et al., 2004; Sherman et al., 2004; Peters et al., 2005; Montoya et al., 2005b; Schön et al., 2007) the predictive value of psychological characteristics on the experimentally induced pain intensity was tested. The following

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>FM</th>
<th>SF</th>
<th>BP</th>
<th>HC</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depressives</td>
<td>7w</td>
<td>2m</td>
<td>7w</td>
<td>2m</td>
<td></td>
</tr>
<tr>
<td>Non-depressives</td>
<td>18w</td>
<td>3m</td>
<td>18w</td>
<td>3m</td>
<td>25w</td>
</tr>
<tr>
<td>ADS-L</td>
<td>17.53</td>
<td>18.83</td>
<td>15.93</td>
<td>6.10</td>
<td>F(3,116) = 11.03; p &lt; .001</td>
</tr>
<tr>
<td>Age</td>
<td>50.50</td>
<td>48.23</td>
<td>50.43</td>
<td>48.40</td>
<td>F(3,116) = 0.61; n.s.</td>
</tr>
<tr>
<td>SD</td>
<td>8.53</td>
<td>7.48</td>
<td>10.04</td>
<td>8.31</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>9 years</td>
<td>21</td>
<td>27</td>
<td>17</td>
<td>4-fields-χ²; p &lt; .008</td>
</tr>
<tr>
<td>&gt; 9 years</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>13</td>
<td>n.s.</td>
</tr>
<tr>
<td>Marital status</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>n.s.</td>
</tr>
<tr>
<td>BMI</td>
<td>32.57</td>
<td>33.64</td>
<td>33.62</td>
<td>30.56</td>
<td>F(3,114) = 2.30; n.s.</td>
</tr>
<tr>
<td>SD</td>
<td>4.46</td>
<td>5.34</td>
<td>5.50</td>
<td>5.03</td>
<td></td>
</tr>
<tr>
<td>Duration of pain disorder (in years)</td>
<td>11.33</td>
<td>10.95</td>
<td>13.76</td>
<td></td>
<td>F(2,65) = 0.56; n.s.</td>
</tr>
<tr>
<td>SD</td>
<td>7.40</td>
<td>9.47</td>
<td>11.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain medication</td>
<td>27</td>
<td>25</td>
<td>16</td>
<td>0</td>
<td>4-fields-χ²; p &lt; .017</td>
</tr>
<tr>
<td>Non-opiates</td>
<td>16</td>
<td>22</td>
<td>13</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>Opiates</td>
<td>8</td>
<td>1</td>
<td>3</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>Antidepressants</td>
<td>15</td>
<td>9</td>
<td>3</td>
<td></td>
<td>4-fields-χ²; p &lt; .017</td>
</tr>
<tr>
<td>Other pain problems</td>
<td>18</td>
<td>21</td>
<td>20</td>
<td>0</td>
<td>4-fields-χ²; n.s.</td>
</tr>
<tr>
<td>Total psychological disorders</td>
<td>16</td>
<td>17</td>
<td>17</td>
<td>0</td>
<td>4-fields-χ²; n.s.</td>
</tr>
<tr>
<td>Alcohol abuse</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>4-fields-χ²; n.s.</td>
</tr>
<tr>
<td>TP</td>
<td>17</td>
<td>15</td>
<td>8</td>
<td>3</td>
<td>F(3,112) = 99.68; p &lt; .001</td>
</tr>
<tr>
<td>SD</td>
<td>1.96</td>
<td>3.29</td>
<td>4.22</td>
<td>3.48</td>
<td></td>
</tr>
<tr>
<td>CP</td>
<td>2</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>F(3,116) = 107.05; p &lt; .001</td>
</tr>
<tr>
<td>SD</td>
<td>0.97</td>
<td>2.98</td>
<td>1.68</td>
<td>1.89</td>
<td></td>
</tr>
<tr>
<td>TPI</td>
<td>53.69</td>
<td>47.10</td>
<td>17.80</td>
<td>6.27</td>
<td>F(3,116) = 48.99; p &lt; .001</td>
</tr>
<tr>
<td>SD</td>
<td>11.99</td>
<td>16.29</td>
<td>10.49</td>
<td>8.82</td>
<td></td>
</tr>
</tbody>
</table>

Note. FM = fibromyalgia; SF = somatoform pain; BP = back pain; HC = healthy controls; w = women; m = men; n.s. = not significant; SD = standard deviation of mean; 4-fields-χ² = four-fields-chi-square-test; TP = tender points; CP = control points; TPI = tender point index.

a FM > BP and FM > HC: p < .001.
b SF > BP and SF > HC: p < .001.
c BP > HC: p < .001.
d BP > HC: p < .008.
e HC > BP: p < .008.
f FM > BP: p < .05.
g SF > BP: p < .05.
h HC > FM and HC > SF and HC > BP: p < .008.
i SF > FM and SF > BP and SF > HC: p < .01.

1 Adjusted x: p ≤ .008.
2 Adjusted x: p ≤ .017.
3 Occasional headache or inflammation or arteriosclerosis of the upper or lower extremities.
4 Depression, anxiety, neurasthenia, personality disorder or combinations of some of these disorders.
traits were assessed: trait anxiety with the German version of the State-Trait-Anxiety-Inventory (STAI-Trait; Laux et al., 1981), pain-related self-instructions with the German Pain-Related Self-Instructions Questionnaire (FSS; Flor et al., 1993), somatization with the German Screening for Somatoform Disorders (SOMS; Rief, 1997), strategies to cope with stress with the German Stress Coping Inventory (SVF120; Janke et al., 1997), disability and affective distress with the German version of the West Haven-Yale Multi-Dimensional Pain Inventory (MPI-D; Flor et al., 1990), and self-efficacy versus externality with the German Competence and Control Beliefs Questionnaire (FKK; Krampen, 1991). Also investigated. In addition, handedness was assessed by the Edinburgh Handedness Inventory (EH; Oldfield, 1971).

2.5. Procedure

At the beginning, participants were informed about possible discomfort that could be elicited by the pictures or the pressure which was, however, temporary and under her control and that she could stop the experiment without any disadvantages. After participants signed their consent the practice pictures were presented, each one for 8 s. The last picture (a negative one) was rated on the SAM. After that the participant was introduced to the pressure pain and how to use the throttle. The questionnaires were filled in at this point. Then the experimental trials were started. Each trial followed the same procedure: the pressure was initiated simultaneously with the picture presentation and continued while watching all seven pictures of a category block. Each picture was shown for 8 s. After the fourth, the fifth, and the seventh picture, the instruction “please rate pain intensity” was shown for 4 s on the screen and the subject rated pain intensity by moving the throttle. Altogether, the pressure was exerted for 72 s. After the seventh picture the pressure was stopped and the subject rated the average valence, arousal and pain relatedness of the picture series. After the last trial participants filled in a post-experimental STAI-State. In the end they completed the questionnaires on pain-related psychological traits.

2.6. Statistical analysis

Because the distribution of the pain intensity means per picture category was skewed, the intensity ratings were (ln-)transformed. To describe the picture category and group effects as well as the effect of repeated measures on pain intensity an ANOVA for repeated measures with the factors picture category (four), group (four) and repetition (four) was conducted. A Greenhouse-Geisser correction was applied for repeated measures tests. Follow-up comparisons between the groups were performed with Tamahane-T2-tests which is insensitive to inhomogeneous group variance. In addition, effect sizes for significant group differences were determined by the difference of the two group means in relation to the variance pooled over all four groups (Cohen, 1988). Intra- and inter-individual differences of the SAM ratings were analyzed with one-way ANOVAs with follow-up comparisons. For the within-comparison of SAM ratings of each group, t-tests were conducted as well, but no z-correction was carried out as the z would have been too small to detect relevant differences in the valence, arousal, and pain relatedness between negative and pain-related pictures. Therefore, the results of the inferential statistical analyses can only be considered descriptive (see Abt, 1987). Moreover, single and multiple correlations between the predictor variables and pain intensity means averaged over all four picture categories for the whole sample, and also for each group were carried out. For all analyses and tests the significance level was set at $z = .05$.

3. Results

3.1. Manipulation check

3.1.1. Intra-individual differences

In all four groups ANOVAs revealed a highly significant effect of picture valence, arousal, and pain relatedness [valence: FM: $F(3,87) = 124.40$, $p < .001$; SF: $F(3,22,67.23) = 69.55$, $p < .001$; BP: $F(3,87) = 150.28$, $p < .001$; HC: $F(2,25,65.30) = 145.35$, $p < .001$; arousal: FM: $F(3,87) = 47.27$, $p < .001$; SF: $F(3,87) = 62.45$, $p < .001$; BP: $F(3,25,65.30) = 89.84$, $p < .001$; HC: $F(2,26,65.62) = 52.91$, $p < .001$; pain relatedness: FM: $F(3,87) = 51.24$, $p < .001$; SF: $F(3,87) = 69.55$, $p < .001$; BP: $F(1.89,54.93) = 134.33$, $p < .001$; HC: $F(2.35,68.06) = 63.63$, $p < .001$]. Also, the t-tests showed significant differences in all four groups on all three dimensions (valence, arousal and pain relatedness), when comparing the negative and pain-related category with positive or with neutral pictures. The positive and neutral pictures were rated as more pleasant, less arousing and were less associated with pain than the negative and the pain-related category (in all cases: $p < .001$).

The t-test comparison of negative with pain-related pictures in FM and SF also showed significant differences on all three dimensions: pain-related pictures were rated as less pleasant ($p < .01$), more arousing ($p < .01$), and more pain-related ($p < .05$) than the negative ones. BP and HC associated the pain-related pictures with more pain than the negative ones (HC: $p < .001$; BP:
p < .01) too, but only HC rated the pain pictures as more unpleasant (p < .01), BP rated them as more arousing (p < .05) than the negative ones.

A comparison of the positive with the neutral pictures revealed a higher pleasantness of the positive category in all four groups (FM, HC, and BP: p < .001; SF: p < .01). All groups except for SF rated the positive pictures as more arousing than the neutral ones (FM and HC: p < .05; BP: p < .01). HC reported more pain relatedness for the positive pictures; this result reached marginal significance (p = .057).

3.1.2. Inter-individual differences

The ANOVAs for the SAM ratings did not differ among the four groups neither in pain-related nor in positive nor neutral pictures. Only the negative category was significantly associated with more pain by BP than by HC (p < .05). SAM rating means and standard deviations of all groups and the results from the ANOVA are depicted in Table 2.

3.2. Picture categories and pain intensity

Fig. 1 shows that there was a significant main effect for group, F(3, 115) = 5.61, p < .001. SF showed a significantly higher pain intensity (averaged over all four picture categories) than both BP (d = .77, p < .01) and HC (d = .75, p < .05). As expected, FM and SF showed comparable pain intensities, but FM did not differ from BP and HC.

There was a significant main effect for picture category, F(3, 315) = 8.62, p < .001, with a significant linear trend (pain-related, negative, neutral, and positive) for

![Fig. 1. Mean pain intensities for patients with FM, patients with SF, patients with BP, and HC participants. Error bars indicate SEM. *p < .05; **p < .01.](image)

<table>
<thead>
<tr>
<th>Group</th>
<th>FM</th>
<th>SF</th>
<th>BP</th>
<th>HC</th>
<th>ANOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive: valence</td>
<td>6.70a</td>
<td>6.73ab</td>
<td>7.47a</td>
<td>7.37a</td>
<td>.254</td>
</tr>
<tr>
<td>Positive: arousal</td>
<td>3.33c</td>
<td>2.87a</td>
<td>2.97a</td>
<td>2.60c</td>
<td>.641</td>
</tr>
<tr>
<td>Positive: pain relatedness</td>
<td>2.90c</td>
<td>2.77a</td>
<td>1.67c</td>
<td>2.33c</td>
<td>.118</td>
</tr>
<tr>
<td>Neutral: valence</td>
<td>5.43c</td>
<td>5.43c</td>
<td>5.17c</td>
<td>5.67c</td>
<td>.524</td>
</tr>
<tr>
<td>Neutral: arousal</td>
<td>2.47c</td>
<td>2.23c</td>
<td>1.87c</td>
<td>1.83c</td>
<td>.645</td>
</tr>
<tr>
<td>Neutral: pain relatedness</td>
<td>2.75c</td>
<td>2.67c</td>
<td>1.93c</td>
<td>1.83c</td>
<td>.153</td>
</tr>
<tr>
<td>Negative: valence</td>
<td>2.27d</td>
<td>2.53d</td>
<td>1.63d</td>
<td>2.20d</td>
<td>.979</td>
</tr>
<tr>
<td>Negative: arousal</td>
<td>6.50b</td>
<td>5.97b</td>
<td>7.13b</td>
<td>5.17b</td>
<td>.289</td>
</tr>
<tr>
<td>Negative: pain relatedness</td>
<td>6.43i</td>
<td>5.87i</td>
<td>7.13b</td>
<td>5.17b</td>
<td>.022</td>
</tr>
<tr>
<td>Pain-related: valence</td>
<td>1.23c</td>
<td>1.60c</td>
<td>1.50c</td>
<td>1.26c</td>
<td>.849</td>
</tr>
<tr>
<td>Pain-related: arousal</td>
<td>7.77i</td>
<td>7.03i</td>
<td>6.60i</td>
<td>6.21i</td>
<td>.053</td>
</tr>
<tr>
<td>Pain-related: pain relatedness</td>
<td>7.32i</td>
<td>7.18i</td>
<td>6.73i</td>
<td>6.21i</td>
<td>.168</td>
</tr>
</tbody>
</table>

**Note:** inter-individual difference: *p < .05; BP > HC; intra-individual difference: Valence: positive > neutral and positive > negative and positive > pain-related.

* p < .001.
* p < .01.
* p < .001; neutral > negative and neutral > pain-related.
* p < .001; negative > pain-related.
* p < .001; positive > pain-related.
* p < .001; neutral > negative and positive > pain-related.
* p < .001; negative > pain-related.
* p < .001.
* p < .01.
* p < .05; neutral > positive.
* p < .01.
* p < .05.
* p = .057.
the within-subject-contrast, \( F(1,105) = 22.60, p < .001 \). Post-hoc tests found significantly higher intensities after pain related (\( M = 3.56; SD = 0.06 \)) compared to negative (\( M = 3.38; SD = 0.06; p < .05 \)) as well as after negative compared to neutral pictures (\( M = 3.26; SD = 0.07; p < .05 \)). Yet, there was no significant difference between the intensities of neutral and positive pictures (\( M = 3.19; SD = 0.07 \)). Thus, the pain-related pictures evoked the highest intensities compared with the other three categories (see Fig. 2).

Moreover, there was a significant effect of repetition, \( F(1.43,149.77) = 140.29, p < .001 \), and an interaction of picture category and repetition, \( F(5,30,556.54) = 2.86, p < .01 \), indicating that pain intensity enhanced depending on the number of pain measurements over time and of the unpleasantness of the pictures (see Fig. 2). For all groups there was a greater rise of pain intensity during neutral compared to negative (\( p < .05 \)) and pain-related pictures (\( p < .001 \)) comparing the differences between the first and fourth measurements of the picture categories.

A significant interaction of picture category and group was, however, not found, \( F(9,105) = 1.62, p = .108 \).

### 3.3. Predictor variables

For the whole sample significant Pearson correlations between pain intensity and traits were quite low. Substantial correlations were only found for pre-experimental state anxiety (\( r = .32 \)) and for positive affect (\( r = -.31 \)). We then conducted an ANCOVA with the factors group (four), picture category (four), and repetition (four) and with these two variables as covariates, but we found no alteration of the significant main effect of groups, \( F(3,105) = 3.41, p < .05 \). On the other hand, BP and SF did not show any significant correlation. In HC significant correlations were found for positive affect (\( r = -.49 \)) and externality (\( r = .41 \)) with the last result pointing out that the more the person believes things to be controlled externally the higher her perceived pain.

Significant correlations in FM with experimental pain intensity were found for pre-experimental state anxiety (\( r = .62 \)), self-efficacy (\( r = -.44 \)), affective distress (\( r = .47 \)), negative pain-related self-instructions (\( r = .49 \)), and trait anxiety (\( r = .42 \)). The correlational data for FM are presented in Table 3.

Comparing the \( z \)-values of the correlations in FM for pre-experimental state anxiety, self-efficacy, affective distress, negative pain-related self-instructions, and trait anxiety with the \( z \)-values of the equivalent correlations in the other three groups revealed significantly higher correlations in FM than in SF and in BP for pre-experimental state anxiety (SF: \( z = -3.33 \); BP: \( z = -4.16 \)). For self-efficacy FM showed a significantly higher correlation than did HC (\( z = 2.15 \)). The correlation for affective distress was significantly higher in FM compared to all the other three groups (SF: \( z = -3.55 \); BP: \( z = -4.16 \); HC: \( z = -3.88 \)). For negative pain-related self-instructions FM showed only a significantly higher correlation than did HC (\( z = -2.32 \)) and for trait anxiety the correlation in FM was significantly higher than in SF (\( z = -2.33 \)) and in HC (\( z = -2.44 \)).

For the whole sample, the explained variance by multiple correlation between predictor variables and actual pressure pain intensity was \( R^2 = .22 (p = .053) \). In FM the predictive value through pain-related traits was highest with \( R^2 = .86 \), though not significant.

![Correlation matrix](image)

**Table 3**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pearson correlation ( r )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive strategies (SVF)</td>
<td>-.25</td>
<td>.142</td>
</tr>
<tr>
<td>Negative strategies (SVF)</td>
<td>.09</td>
<td>.342</td>
</tr>
<tr>
<td>Depression (ADS)</td>
<td>.26</td>
<td>.136</td>
</tr>
<tr>
<td>Positive affect (PANAS)</td>
<td>-.29</td>
<td>.101</td>
</tr>
<tr>
<td>Negative affect (PANAS)</td>
<td>.23</td>
<td>.168</td>
</tr>
<tr>
<td>Pre-experimental state anxiety</td>
<td>.62**</td>
<td>.002</td>
</tr>
<tr>
<td>Self-efficacy (FKK)</td>
<td>-.44*</td>
<td>.025</td>
</tr>
<tr>
<td>Externality (FKK)</td>
<td>.17</td>
<td>.232</td>
</tr>
<tr>
<td>Disability (MPI-D)</td>
<td>.12</td>
<td>.314</td>
</tr>
<tr>
<td>Affective distress (MPI-D)</td>
<td>.47*</td>
<td>.018</td>
</tr>
<tr>
<td>Coping pain-related self-instr.</td>
<td>-.07</td>
<td>.380</td>
</tr>
<tr>
<td>(FSS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Negative pain-related self-instr. (FSS)</td>
<td>.49*</td>
<td>.014</td>
</tr>
<tr>
<td>Somatization (SOMS)</td>
<td>.10</td>
<td>.334</td>
</tr>
<tr>
<td>Trait anxiety (STAI-Trait)</td>
<td>.42*</td>
<td>.033</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>.86</td>
<td>.198</td>
</tr>
</tbody>
</table>

* \( p < .05 \).
** \( p < .01 \).
(\(p = .198\)), in BP it was \(R^2 = .69\) (\(p = .238\)), in SF \(R^2 = .54\) (\(p = .568\)) and in HC \(R^2 = .55\) (\(p = .613\)).

4. Discussion

In the present study, we investigated the specificity of affective pain modulation in patients with fibromyalgia (FM) by comparing them with patients with somatoform pain (SF), chronic back pain (BP), and pain-free controls (HC). We used a laboratory-based mood induction method with positive, neutral, negative, and pain-related stimuli and assessed pressure pain intensity. The hypothesis that FM and also SF would show enhanced pain intensities after negative and especially after pain-related pictures compared to HC and BP was not confirmed. A reason why we did not find a clear modulatory effect in FM and SF could be that there was a ceiling effect. Especially in these groups the pressure stimulus might have been too strong. Indeed, FM and SF were more likely to rate the pain stimulus so extreme that they lifted the lever weight. Further studies should include a lower pressure.

As in the previous studies which also used IAPS pictures for emotional priming (De Wied and Verbaten, 2001; Meagher et al., 2001; Kenntner-Mabiala and Pauli, 2005) we also found enhanced pain intensities after negative compared with positive pictures. To our knowledge, our study is the first to demonstrate an affective pain modulation using pressure pain stimuli. Therefore, our finding speaks to the generality of the affective modulation phenomenon across pain tests. Also, we found higher pain intensities after pictures with specific pain-related cues than after negative pictures without specific pain relevance (De Wied and Verbaten, 2001; Wunsch et al., 2003; Godhino et al., 2006) and our study is the first to find this linear trend from positive, neutral, negative to pain-related pictures in a within-subject design. This emotional modulation of pain intensity supports Lang’s motivational priming hypothesis (Lang, 1995; Lang et al., 1997) as a plausible theoretical framework for pain perception. Strikingly though, neither in SF nor in HC we found a significant main effect for picture content.

In previous priming procedures, the primes were typically presented prior to the pain stimuli. In our study we presented pictures and pain stimuli simultaneously. Although this procedure has the advantage of being more naturalistic it may be problematic because affective categories may not be equally interesting. Different categories may draw attention away from the pain experience. However, the observation that pain was not higher during neutral pictures does not support this possibility.

Although we did observe an affective modulation of pain intensity in all participants our data does not support Montoya’s findings (2005b) which suggested that negative priming differentially leads to more intense clinical pain in FM compared to patients with musculoskeletal pain. Maybe this is because experimental pain does not perfectly mimic clinical pain which is more closely related to the patient’s affective state. Another reason why we did not find an interaction may be that the positive pictures did not reduce pain relative to neutral ones in any one of the four groups we studied here. This is surprising because the same stimulus material yielded the expected effects in the study by De Wied and Verbaten (2001). An apparent difference between their and our study is that participants were considerably older in the present study and the positive IAPS pictures may work differently in different populations. Also, the positive pictures were rated as less arousing than the negative and the pain-related pictures so that the latter attracted more attention. The IAPS pictures as a whole may not have been personally relevant for the populations examined here. Other studies which found higher pain intensities in FM compared to osteoarthritis patients after negative stimulation used an induction method with a higher personal relevance, namely, the discussion of personal conflicts (Davis et al., 2001).

Although our study did not discover an interaction between diagnostic group and affective priming and although we could not eliminate the limitation that pain medication was not controlled, significant group differences were found. Different from our expectation, only SF had higher pain ratings than did BP and HC which did not differ, but FM patients were in between and did not differ significantly from BP and HC. The fact that FM and SF reported very similar pain intensities suggests that the postulated high sensitivity to pressure pain in FM is not specific to this disorder.

In FM there were significant correlations between the actual pain intensity in the experiment and psychological characteristics assessed by questionnaire. Moreover, the correlations for variables like state anxiety, affective distress, trait anxiety, self-efficacy beliefs, and negative pain-related self-instructions were significantly higher in FM than in the other groups. This further highlights the importance of psychological factors in fibromyalgia. However, an obvious limitation is the correlational nature of these findings. The necessary next step will be to replicate these exploratory findings in studies with larger sample sizes per group and then to integrate them in a specific model for the prediction of pain by psychological characteristics in fibromyalgia.

In sum, this study confirmed that emotional priming modulates pain perception and that pain is particularly strong when pain-related stimuli are used. Although we observed that psychological characteristics are related to pain perception in patients with fibromyalgia the emotional priming did not affect them more than other relevant patient groups or healthy controls. The
overall elevated pain sensitivity observed in somatofom pain disorder and fibromyalgia may be cause or effect of the disorders. Future studies should examine whether successful treatment may reduce not only the clinical pain but also pain perception to experimental stimulation. Also, an important aim for future research should be to find out which psychological factors are specifically involved in the pain of fibromyalgia and whether they are cause or effect of the disorder.

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