Attentional Bias Toward Negative Information in Patients with Fibromyalgia Syndrome

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Abstract

Objective. In addition to central nervous sensitization, affect dysregulation constitutes an important factor in the pathogenesis of fibromyalgia syndrome (FMS). The present study is concerned with emotional influences on information processing in FMS. The hypothesis of attentional bias, i.e., selective processing of negatively connoted stimuli, was tested.

Methods. Twenty-seven female FMS patients and 34 healthy women undertook an emotional modification of the Stroop task. Subjects had to decide whether the colors of positive, negative, and neutral adjectives accorded with color words presented in black. Attentional bias was defined as delay in color naming of emotional words relative to neutral words. Affective and anxiety disorders, pain severity, as well as medication were considered as possible factors mediating the expected interference.

Results. Patients showed marked attentional bias, manifested in a greater response delay due to negative words compared with the control group. Among the clinical features, pain severity was most closely associated with the extent of the interference. While depression played only a subordinate role, anxiety and medication were without effect.

Conclusions. The study provides evidence of emotionally driven selective attention in FMS. Attentional bias to negative information may play an important role in the vicious circle between negative affective state and pain augmentation. In the management of FMS pain, strategies aiming at conscious direction of attention may be helpful, e.g., imagery techniques or mindfulness training.

Key Words. Fibromyalgia; Chronic Pain; Emotion; Selective Attention; Emotional Stroop Test

Introduction

Fibromyalgia syndrome (FMS) is a chronic condition of widespread pain accompanied by symptoms such as morning stiffness, depression, fatigue, sleep disturbance, and impaired mental functioning [1]. According to current knowledge, hyperalgesia occurs due to hypersensitivity of central nociceptive pathways and deficient pain-inhibiting mechanisms [2]. Affective modulation of the processing of pain-related information has also been implicated in FMS pathology [3,4]. This is supported by neuroimaging studies showing more pronounced hyperactivity of brain areas mediating affective pain processing than of structures related to sensory pain [5–7]. It has been hypothesized that FMS patients are particularly vulnerable to the effects of negative mood, in the sense that pain potentiation during experiences of sadness, anxiety, or disgust may be stronger than in healthy individuals [8–10]. Further aberrances in emotion processing include impaired affect...
The present study is concerned with emotional influences on information processing in fibromyalgia. Attentional bias in terms of selective processing of negative information is believed to play an important role in psychopathology [16]. Enhanced attention toward threatening or general negative cues was reported for instance, in depression, anxiety disorders, posttraumatic stress, and personality disorders [17–21]. Selective attention to emotionally relevant stimuli interferes with information processing by capturing processing resources, thereby disrupting ongoing cognitive activity. This effect is most frequently studied using the Emotional Stroop Test. In this experimental paradigm, a subject is asked to name the colors of words with different emotional contents while ignoring the word meaning. Attentional bias is reflected by longer time to name the color of emotional as compared with neutral words of comparable frequency in everyday speech. A large number of studies have documented the fact that individuals with psychiatric disorders exhibit decelerated color naming of words with general negative connotations, or expressions specifically related to their diseases [16].

In the field of chronic pain, the Emotional Stroop Test has mainly been used to investigate the hypothesis of hypervigilance to pain, i.e., unintentional attention toward pain-related information, which has been suggested to be relevant in the appearance of the disorder [22,23]. A recently published meta-analysis, which included 22 studies based on the Emotional Stroop Test, confirmed the occurrence of this effect but also alluded to its relatively small size and limited robustness [24]. To date, only a single study applied the Emotional Stroop Test in fibromyalgia research [25]. Here, patients and healthy subjects had to name the colors of words describing typical symptoms of FMS as well as disease-unrelated words with positive, negative, or neutral connotations. Patients showed significantly longer response times to the words from all categories, which was interpreted as indicative of general hypervigilance in FMS, i.e., a patients' propensity to focus on task-irrelevant information.

In the current study, a variant of the Emotional Stroop Test was applied in order to investigate the hypothesis of selective processing of affectively negative information in FMS. The presence of a negative attention bias seems plausible taking into account the aforementioned affective dysregulation as well as disturbed affect balance and high levels of catastrophizing [11,12]. In addition, fibromyalgia exhibits high comorbidity with affective and anxiety disorders, and the patients display considerable elevations in depressed mood, difficulties in emotion recognition as well as disease-unrelated words. No group difference was expected for interference regarding the positive words.

Due to the complex nature of fibromyalgia and its overlap with other disease entities, it seemed worthwhile in the present study to also investigate the contribution of specific features of FMS pathology to the expected attentional bias. For this purpose, psychiatric comorbidity was diagnosed, and clinical questionnaires on pain severity, depression, and anxiety were applied. We focused on depression and anxiety because of their high prevalence in FMS and also in consideration of reports on attentional bias in patients suffering from affective and anxiety disorders [18,20,21].

Methods

Participants

Twenty-seven female FMS patients with a mean age of 52.7 years (SD = 9.2 years) participated in the study. They were recruited via interdisciplinary treatment programs for chronic pain patients, self-regulating communities, and the German Fibromyalgia Association. The patients were examined either by an anesthesiologist or specialist in pain medicine, and met the American College of Rheumatology criteria for FMS [28]. Exclusion criteria for participation comprised inflammatory causes of pain, neurological disorders, metabolic abnormalities, and severe somatic (e.g., cancer) or psychiatric (e.g., psychosis) diseases. Mean illness duration, i.e., the interval from first diagnosis of FMS, was 6.0 years (SD = 5.6 years). Tender point testing revealed an average of 15.3 active tender points (SD = 2.8). Sixteen (59.3%) patients were diagnosed with comorbid depression and four (14.8%) with comorbid anxiety disorders (panic disorder, generalized anxiety disorder, or phobia). At the time of assessment, eight (29.6%) patients were being treated with antidepressants, nine (33.3%) were using non-opioid analgesics, two (7.4%) opiates, and one (3.7%) anxiolytics. Mean time of education, which was taken as an estimate of educational background, was 13.7 years (SD = 3.1 years).

The control group included 34 healthy women with a mean age of 53.9 years (SD = 8.4 years), who were recruited from local institutions for adult education and via personal contacts. Control subjects met the same exclusionary criteria as did the patients but were additionally required not to have any pain disorders. None of the control subjects were diagnosed with depression or anxiety disorders. None of them used antidepressants, analgesics, anxiolytics, or opiates. Mean time of education in the control group was 13.8 years (SD = 2.5 years). The patient and control groups did not differ significantly in terms of age (F[1,59] = 0.38, P = 0.56, partial eta squared <0.01) or time of education (F[1,59] = 0.17, P = 0.94, partial eta squared <0.01).
Clinical Interviews and Questionnaires

In order to diagnose comorbid psychiatric disorders, the Structured Clinical Interview for Axis I Disorders of the Diagnostic and Statistical Manual for Mental Disorders (SCID) [29] was applied. Clinical pain severity was assessed using the short form of the McGill Pain Questionnaire (MPQ) [30]. The instrument provides the following parameters: 1) sensory pain index (possible range 0–33); 2) affective pain index (possible range 0–12); 3) total pain index (possible range 0–45); 4) current pain intensity (possible range 0–100); 5) global evaluation of pain intensity (possible range 0–5); and 6) sum score (possible range 0–145). The Beck Depression Inventory (BDI) [31] was used to quantify the severity of symptoms of depression (possible range 0–33). The State Trait Anxiety Inventory (STAI) [32] was included to evaluate current and habitual anxiety levels (possible range 20–80). Higher scores indicate stronger symptom severity in each of the scales.

Emotional Stroop Test

A German version of the Emotional Stroop Test was applied, which has been successfully used in previous studies [19,33]. Stimuli comprised 40 positive (e.g., happy, beautiful), 40 negative (e.g., disgusting, cruel), and 40 neutral (e.g., liquid, quiet) adjectives drawn from a word battery selected for the purpose of emotion research [34]. The words from the three categories were matched for length and frequency in the German language. The mean normative ratings for valence and arousal on the Self-Assessment Manikin scale (SAM) [35] were as follows (possible scores 1–9; higher values for more negative valence and stronger arousal): positive words, valence: 1.80, arousal: 4.40; negative words, valence: 6.68, arousal: 4.25. Words were presented sequentially in a random order in red, yellow, green, or blue. As a restriction, only two words from the same category were allowed to directly succeed each other. Five-hundred milliseconds after stimulus onset, a color word (red, yellow, green, or blue) printed in black was additionally presented below the adjective. The participant had to decide as quickly as possible whether or not the color of the adjective corresponded to the color word by pressing one of two buttons. Both words disappeared with the keystroke. In 50% of cases, the color of the adjective and the color word were concordant. Trials were separated by an interval of 1500 ms during which a fixation cross was displayed on the screen. If the subject did not respond during the 1500 ms after appearance of the color word, it was replaced by the fixation cross, and the reaction time of the respective trial was classified as missing. Only the data of subjects who had a miss rate of less than 30%, i.e., at least 90 valid trials, were included in the analysis. Due to the application of this criterion, one FMS patient and one control subject had to be excluded from the original sample. The average numbers of missing trials in the FMS and control groups were 7.1 (SD = 6.8) and 4.1 (SD = 5.8), respectively. The numbers did not differ significantly as a function of group ($F(1,59) = 3.51$, $P = 0.07$) or word category ($F(2118) = 2.28$, $P = 0.11$).

Following task completion, the 120 adjectives appeared once more on the screen, and the participant rated them according to valence and arousal on the SAM [35]. Words were presented in 74-point Arial font on a white background at a distance of approximately 1 m using Presentation Software (Neurobehavioral Systems, Albany, CA). All instructions were given in written form.

Interference scores for the positive and negative words were computed as indices of attentional bias. In the Emotional Stroop Test, interference is defined as the difference between the time taken to name the colors of affectively valenced words and the time needed to name the colors of neutral words [16]. The scores thus reflect emotional modulation of processing speed, taking neutral information as a reference. While a positive interference score indicates attentional interference caused by emotional stimuli, a negative score represents attention facilitation [21,36]. In addition to the interference scores, mean simple reaction times were computed for the trials from the three word categories.

Procedure

Medical examination and diagnoses were conducted prior to the experiment. At the beginning of the experimental session, a clinical psychologist recorded the participants’ demographic data and clinical history, conducted the SCID interview and presented the questionnaires. The Emotional Stroop Test was subsequently undertaken in accordance with the description above. Participants were asked not to consume analgesic drugs 24 hours prior to the commencement of the study. The use of antidepressants and other medication was not interrupted. In addition, subjects were requested not to smoke or drink either alcohol or beverages containing caffeine for 3 hours prior to the experimental session. All participants gave their written informed consent to the study.

Data Analysis

For the comparison of the study groups, a multivariate analysis of variance (MANOVA) procedure was applied. Dependent variables comprised the interference scores, the reaction times in the trials including positive, negative and neutral words, and the scales of the clinical questionnaires. We also analyzed potential biases related to comorbid affective disorders and medication use by comparing subsamples of patients diagnosed and not diagnosed with depression and taking and not taking antidepressants, respectively. For this purpose, two further MANOVA models were computed with the interference scores as dependent variables. The number of patients suffering from comorbid anxiety disorders ($N = 4$) was too low to investigate their impact based on this approach. As patients were asked to abstain from analgesics prior to the experimental session, and further where only one patient was being treated with anxiolytics, we did not perform further analyses for these drugs.

The SAM ratings on emotional valence and arousal were analyzed using repeated-measures ANOVAs with the
between-subjects factor group (FMS vs control group) and the within-subject factor word category (positive, negative, and neutral). This allowed for the assessment of the suitability of the selected words in the induction of positive and negative emotions, as well as for the assessment of possible group differences in the evoked emotions.

In order to evaluate the possible impact of pain severity, depressiveness, and anxiety on task performance, Pearson correlations were computed between the questionnaire data and the parameters of the Emotional Stroop Test. In addition, the effects of pain, depressiveness, and anxiety were directly compared by means of stepwise regression analyses. Due to high correlations between the questionnaire scales, multi-collinearity occurred. Therefore, only the sum score of the MPQ, the BDI, and the state scale of the STAI were applied as predictors.

Results

Figure 1 displays the interference scores for the positive and negative words in the FMS patients and the control group. While the two groups exhibited similar scores for the positive words, scores for the negative words were far higher in the patients than healthy subjects. Accordingly, the MANOVA revealed a significant group effect for the negative but not the positive words (negative: $F[1,59] = 5.11$, $P = 0.028$, partial eta squared $= 0.080$; positive: $F[1,59] = 0.01$, $P = 0.92$, partial eta squared $< 0.01$). The simple reaction times to the words of the three categories are given in Table 1. The comparison between study groups revealed significantly longer latencies for the negative words in FMS patients. Additionally, possible differences as a function of word category were investigated. Within the FMS group, reaction times were significantly longer for negative vs positive ($t[26] = 2.57$, $P = 0.016$) and neutral ($t[26] = 4.66$, $P < 0.01$) words. In the control group, reaction times to negative word significantly exceeded those seen for positive words ($t[25] = 2.67$, $P = 0.012$).

The MANOVA comparing the interference scores of patients with and without comorbid depression did not reveal a significant difference (positive words: $F[1,25] = 0.21$, $P = 0.65$, partial eta squared $< 0.01$; negative words: $F[1,25] = 0.35$, $P = 0.65$, partial eta squared $= 0.014$). The same held true for the model regarding the use of antidepressants (positive words: $F[1,25] = 0.67$, $P = 0.42$, partial eta squared $= 0.026$; negative words: $F[1,25] = 0.37$, $P = 0.55$, partial eta squared $= 0.015$).

The SAM ratings on the words of the three categories are depicted in Figure 2. In both study groups, valence ratings on the positive, negative, and neutral words showed the expected pattern. While the ANOVA revealed a significant effect of word category ($F[2,118] = 442.01$, $P < 0.01$, partial eta squared $= 0.88$), neither the group difference nor the interaction between group and word category reached significance (group: $F[1,59] = 0.30$, $P = 0.86$, partial eta squared $< 0.01$; interaction: $F[2,118] = 1.37$, $P = 0.26$, partial eta squared $= 0.023$). Post-hoc tests comparing the valence ratings of the three-word categories showed significant differences in all cases (neutral vs positive: $t[60] = 23.42$, $P < 0.01$; neutral vs negative: $t[60] = 23.34$, $P < 0.01$; positive vs negative: $t[60] = 17.57$, $P < 0.01$). Negative words were perceived as more arousing than were positive and neutral words. Again, ANOVA revealed a significant effect of word category ($F[2,118] = 228.21$, $P < 0.01$, partial eta squared $= 0.80$) but no group effect or interaction (group: $F[1,59] = 0.003$, $P = 0.96$, partial eta squared $< 0.01$; interaction: $F[2,118] = 0.42$, $P = 0.66$, partial eta squared $> 0.01$).

Table 1  Mean reaction times (in millisecond) in the trials including positive, negative, and neutral words (SD in brackets), F values, P values, and partial eta squared for the group comparison

<table>
<thead>
<tr>
<th></th>
<th>FMS Patients</th>
<th>Control Group</th>
<th>$F[1,59]$</th>
<th>$P$</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>795.9 (103.5)</td>
<td>743.3 (159.4)</td>
<td>2.19</td>
<td>0.14</td>
<td>0.036</td>
</tr>
<tr>
<td>Negative</td>
<td>822.0 (114.4)</td>
<td>749.0 (145.4)</td>
<td>4.55</td>
<td>0.037</td>
<td>0.072</td>
</tr>
<tr>
<td>Neutral</td>
<td>785.3 (86.5)</td>
<td>733.8 (146.9)</td>
<td>2.60</td>
<td>0.11</td>
<td>0.042</td>
</tr>
</tbody>
</table>
Emotional Bias in Fibromyalgia

Figure 2 Self-Assessment Manikin (SAM) ratings in fibromyalgia syndrome (FMS) patients and control persons (ranges for FMS group, valence positive: 1.1–5.0, valence neutral: 2.9–5.2, valence negative: 4.3–8.8, arousal positive: 4.1–9.0, arousal neutral: 5.2–9.0, arousal negative: 1.4–8.8; ranges for control group, valence positive: 1.0–4.0, valence neutral: 2.6–5.6, valence negative: 4.4–9.9, arousal positive: 4.3–8.9, arousal neutral: 5.2–7.8, arousal negative: 1.7–5.6; bars represent standard errors of the mean).

Post-hoc testing yielded significant differences between arousal ratings on positive and negative words (t[60] = 16.86, P < 0.01) as well as between neutral and negative words (t[60] = 18.19, P < 0.01). In contrast, positive and neutral words did not differ significantly (t[60] = 1.38, P = 0.17).

In acknowledgment of the significant difference between the arousal ratings on the positive and negative words, a possible impact of arousal on the group differences in reaction times and attentional interferences was controlled in additional ANOVA models. The inclusion of the arousal ratings of the respective emotion categories as covariates did not change the results (interference positive: F[1,58] = 0.01, P = 0.91, partial eta squared <0.01; interference negative: F[1,58] = 4.89, P = 0.031, partial eta squared = 0.078; reaction time positive: F[1,58] = 2.14, P = 0.15, partial eta squared = 0.036; reaction time negative: F[1,58] = 4.33, P = 0.042, partial eta squared = 0.069; reaction time neutral: F[1,58] = 2.41, P = 0.13, partial eta squared = 0.040).

The questionnaire data are summarized in Table 2. FMS patients had significantly higher scores on each of the six scales of the MPQ, as well as the BDI and the state and trait scales of the STAI. Table 3 shows the correlations between the questionnaire scales and the parameters of the Emotional Stroop Test. Reaction times to negative words were significantly positively correlated with each scale of the MPQ; the interference score for the negative words was significantly positively correlated with the MPQ scales and the BDI.

Stepwise regression analyses were computed with the MPQ sum score, the BDI, and the STAI state scale as predictors and the interference scores and reaction times as dependent variables. The MPQ sum score entered the models for the interference score and reaction time for negative words as a significant predictor (interference score negative words: R² = 0.25; MPQ sum score: Beta = 0.25, P = 0.049; BDI: Beta = 0.11, P = 0.46; STAI state: Beta = -0.12, P = 0.36; reaction time negative words: R² = 0.26; MPQ sum score: Beta = 0.26, P = 0.047; BDI: Beta = 0.76, P = 0.01; STAI state: Beta = -0.015, P = 0.91; collinearity statistics, MPQ sum score: tolerance = 1.00, VIF = 1.00; BDI: tolerance = 0.68, VIF = 1.47; STAI state: tolerance = 0.90, VIF = 1.11). In the remaining models, none of the predictors reached significance.

Table 2 Statistics of questionnaire scales (M = mean, SD = standard deviation), F values, P values, and partial eta squared for the group comparison

<table>
<thead>
<tr>
<th></th>
<th>FMS Patients</th>
<th>Control Group</th>
<th>F[1,59]</th>
<th>P</th>
<th>Partial Eta Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>Range</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>MPQ: sensory pain</td>
<td>20.3</td>
<td>5.0</td>
<td>10–28</td>
<td>0.8</td>
<td>4.0</td>
</tr>
<tr>
<td>MPQ: affective pain</td>
<td>6.6</td>
<td>2.3</td>
<td>1–10</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>MPQ: total pain</td>
<td>26.7</td>
<td>6.7</td>
<td>14–38</td>
<td>1.1</td>
<td>4.9</td>
</tr>
<tr>
<td>MPQ: current pain intensity</td>
<td>53.8</td>
<td>16.5</td>
<td>18–77</td>
<td>0.3</td>
<td>1.7</td>
</tr>
<tr>
<td>MPQ: global evaluation</td>
<td>3.0</td>
<td>0.6</td>
<td>1–5</td>
<td>0.06</td>
<td>0.2</td>
</tr>
<tr>
<td>MPQ: sum score</td>
<td>80.7</td>
<td>21.9</td>
<td>32–109</td>
<td>1.4</td>
<td>5.5</td>
</tr>
<tr>
<td>BDI</td>
<td>19.5</td>
<td>11.4</td>
<td>5–31</td>
<td>5.7</td>
<td>4.1</td>
</tr>
<tr>
<td>STAI: state</td>
<td>47.4</td>
<td>9.6</td>
<td>34–65</td>
<td>40.6</td>
<td>7.5</td>
</tr>
<tr>
<td>STAI: trait</td>
<td>52.1</td>
<td>9.2</td>
<td>36–76</td>
<td>37.6</td>
<td>6.1</td>
</tr>
</tbody>
</table>

BDI = Beck Depression Inventory; FMS = fibromyalgia syndrome; MPQ = McGill Pain Questionnaire; STAI = State Trait Anxiety Inventory.
Discussion

As a main finding, the study revealed stronger interference on the Emotional Stroop Test in patients with fibromyalgia in comparison to healthy subjects, manifested as markedly greater response delays in the color naming of negative vs neutral adjectives. Furthermore, patients displayed longer simple response times to negative words than did the control group. The findings support the notion of selective attention to aversive stimuli in FMS, which interferes with optimal information processing. It would seem that negative information recruits a disproportionately large amount of cognitive resources, thereby slowing simultaneous concurrent processes [16]. As an alternative interpretation, the group differences could be ascribed to a more general deficit in information processing in FMS [37]. This is however contradicted by the finding that increased interference arose only for negative but not positive cues. In addition, in a recent study [38], FMS patients and healthy subjects did not differ on the original form of the Stroop Test [39], supporting the view that the stronger interference in FMS specifically relates to exaggerated cognitive processing of affectively negative information. The conclusion that emotional interference occurs in information processing is also in line with the observation of impaired emotional decision making in FMS [38]. On the Iowa Gambling Task [40], patients exhibited attenuated learning, stronger perseveration, and a higher number of disadvantageous decisions. As patients did not differ from healthy controls in their general intelligence, their lower performance may be ascribed to abnormal processing of emotional cues rather than an actual cognitive deficit.

The suitability of the adjectives which were applied in the study in order to elicit the various affective states was confirmed by the SAM valence ratings, which concurred with the addressed categories of emotion. Valence and arousal ratings for the negative adjectives did not differ between groups, such that the increased interference scores and longer reaction times of FMS patients are unlikely to be due to group differences in the appraisal of the stimuli nor to the magnitude of the affective response. Rather, the findings may be attributable to greater selective attention toward aversive cues and increased cognitive elaboration of negative information in FMS. This is also supported by the fact that the pattern of results remained unchanged when the intensity of the response indexed by the arousal ratings was statistically controlled for. However, it should be noted that the arousal ratings for the positive adjectives were overall relatively low. Therefore, the possibility that the comparatively small interference scores for positive stimuli obtained in both groups may at least partly be due to a limited affective response, which may in turn have restricted the likelihood of detect grouping differences for positive cues, cannot be ruled out.

The results of the clinical questionnaires confirm earlier reports of increased depression and anxiety in FMS [8,15,37,41]. In addition to the six scales of the MPQ, higher BDI values were significantly associated with increased negative Stroop interference. One may therefore infer that symptoms of depression which accompany FMS to some degree contribute to attentional bias. This is consistent with reports of selective processing of negatively valenced information in depressive patients [16,21]. However, the direct comparison of the impacts of pain, depression, and anxiety on interference and simple response times to negative adjectives by means of regression analysis show that pain severity accounted for the largest portion of variance in both variables. It was thus perceived intensity of clinical pain that was most closely related to the expression of attentional bias. This is also in agreement with the lack of impact of categorically diagnosed depression and antidepressive medication on Stroop interference. Taken together, these findings are compatible with the view that there is an association between severity of fibromyalgia pain and attentional bias toward affectively negative information.

Most of the available research on attentional bias in chronic pain patients has focused on information directly related to pain experience [24]. In addition to the...
Emotional Stroop Test, the dot probe and spatial cuing tasks were also applied for this purpose. Interestingly, the meta-analysis of Crombez et al. [24] showed that the magnitude of the bias was higher for information pertaining to the sensory, as compared with the affective, dimension of pain. Mean effect sizes were 0.32 for sensory pain and 0.08 for affective pain. Using the dot probe task, this pattern has been shown in patients with rheumatoid arthritis [42] and chronic musculoskeletal pain [43], as well as in conditions such as acute and chronic low back pain [44]. The specificity of the effect to sensory pain information seems to contrast with the attentional bias induced by affective cues presently observed in patients suffering from FMS. This however is in line with reports of a particular vulnerability of FMS patients to the effects of negative affective states. Davis et al. [45] found marked exacerbation of clinical pain due to negative mood induced via an imagery procedure in FMS patients but not in individuals with chronic osteoarthritis. Montoya et al. [8] showed an enhancement of pain reports during the viewing of negative affective pictures in FMS patients, which did not arise in individuals with musculoskeletal pain. Taken together, these findings are in accordance with the notion of there being a particular involvement of affective factors in the occurrence of FMS pathology [3,7,10].

Our findings are also consistent with psychophysiological investigations of emotional processing in fibromyalgia. Bartley et al. [46] presented FMS patients with sets of pleasant and unpleasant emotionally charged pictures while assessing subjective and bodily responses. Unpleasant stimuli elicited greater corrugator activity modulation and stronger self-reported displeasure in patients as compared with healthy controls, which was interpreted as indicative of a greater defensive response to aversive cues. No group differences arose for subjective or bodily reactions to pleasant and neutral pictures. González-Roldán et al. [47] assessed psychophysiological responses to facial expressions of pain, anger, and happiness in FMS. Faces expressing pain and anger triggered enhanced corrugator activity as well as elevated N100 amplitudes and Theta power of the electroencephalogram (EEG). Besides a stronger defensive reaction, the results suggest increased mobilization of attentional resources to facially expressed negative affect.

A number of psychological and physiological pathways are widely known to connect emotion and pain perception. While increases in pain sensitivity could be reliably achieved by experimental induction of negative affective states [48–50], the experience of pain, particularly as a chronic state, is a powerful source of mood disturbances and emotional disorders [51]. Attentional bias may be relevant to this vicious circle. Classical theories of emotion, as well as clinical models, postulate a bidirectional interaction between aversive affect and selective attention to negative events [52,53]. By this means, attentional focus on negative information and negative emotional state mutually aggravate each other, thereby increasing pain severity. On a central nervous level, the medial part of the neocortex of nociception is responsible for affective and cognitive modulation of pain processing. In particular, the cingulate, amygdala, and medial prefrontal cortex are crucial in mediating the effects of psychological factors such as attention, depression, and anxiety on the experience of pain [50,54,55]. The pathogenetical significance of this network to fibromyalgia is underlined by reports of its exaggerated activity during experimental pain stimulation [5,7]. Attentional bias may also augment pain processing at this level. A functional magnetic resonance imaging study based on a modified version of the Emotional Stroop Test suggested involvement of the rostral anterior cingulate, amygdala, and prefrontal structures in task execution [36]. According to these authors, the resolution of the emotional conflict within the task depends on top-down modulation of the amygdala by the anterior cingulate. The structures active during the Emotional Stroop Test also form part of the medial pain matrix and thus may be viewed as potential neural interfaces between emotionally driven selective attention and pain experience. Pain modulation due to cognitive-affective states is also believed to be relevant in the process of pain chronification [56]. Accordingly, the medial pain system, in particular the medial prefrontal cortex and anterior cingulate, is viewed as crucial to central sensitization and the transition from acute to chronic pain in disorders such as fibromyalgia [5,6].

A limitation of the study pertains to its relatively small sample size. This particularly holds true for the stratified analyses within the FMS group. The power of the statistical tests used for the subgroup comparisons was comparatively low such that possible effects of comorbid depression and antidepressant use may not have been detected. The present comparison between FMS patients and healthy subjects revealed an effect size of 0.58 (Cohen’s d) for inference for negative cues. Taking this effect size, as well as an alpha level of 5% and a Beta error of 20% as a basis, power analysis reveals a required sample size of 13 per study group. However in their meta-analysis, Crombez et al. [24] reported a mean effect size of 0.17 for Stroop tasks including pain-related information applied to samples of chronic pain patients. According to this estimation, the far higher number of 141 participants per group would be required. Further restrictions arise from the methods used for the purpose of psychiatric diagnostics. The SCID interviews were not recorded in order to ensure their diagnostic reliability by independent raters. The BDI and STAI may have been suboptimal instruments, given that they are not well validated in chronic pain samples, and further that their scores may be enhanced due to somatic symptoms. The interruption of the patients’ intake of analgesics prior to the study may be another important issue. The resulting increase in current pain experience may have particularly affected the correlation of the MPQ scales with interference scores and simple reaction times. Future studies may also make use of additional paradigms quantifying attentional bias. To this end the dot probe task, for example, may be helpful. Some authors consider that this task may yield more
reliable and robust differences between clinical groups and healthy individuals than does the Emotional Stroop Test [21,24]. Moreover, behavioral measures of attentional bias in FMS may be complemented by psychophysiological methods. In particular, the application of event-related potentials of the EEG may be useful for detecting central nervous correlates of selective processing of negative stimuli.

Finally, possible implications of the present findings to the treatment of fibromyalgia may be considered. The likely involvement of negative attentional bias in the mutual reinforcement of disturbed mood and pain severity is particularly relevant with respect to the optimal composition of cognitive therapy in pain management. In addition to classical cognitive techniques such as validity testing or reappraisal, specific attentional training may also be helpful. Self-control strategies are advisable to enhance ability to consciously withdraw attention from possible stressors or dysfunctional cognitions [25]. Such measures may include imagery techniques or strategies aiming at the deliberate control of attention, i.e., mindfulness training [57].

In summary, the study provided evidence for substantial attentional bias toward negative information in patients with fibromyalgia. According to the present data, it is unlikely that this aberrance arose as a consequence of psychiatric comorbidity or medication use. Although the presence of depressive symptoms correlated with Stroop interference and reaction time to negative words, the bias mainly related to the patients’ primary pain complaints. Selective attention for negative information may be a crucial factor in the vicious circle between negative affective state and pain augmentation. On a central nervous level, this interaction becomes apparent in the overlap between the networks mediating emotional influence on cognition and affective pain processing.

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