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# The Role of Fear of Movement and Injury in Selective Attentional Processing in Patients With Chronic Low Back Pain: A Dot-Probe Evaluation

Jeffrey Roelofs, Madelon L. Peters, Thijs Fassaert, and Johan W. S. Vlaeyen

**Abstract:** **The present study sought to investigate to what extent patients with chronic low back pain and pain-free control subjects selectively attend to pain-related stimuli as measured with 2 dot-probe tasks with word stimuli and pictorial stimuli. Selective attentional processing was measured by means of 3 indices: the bias index, a congruency effect, and an incongruency effect. Pain-related fear as a trait measure (Tampa Scale for Kinesiophobia [TSK]) was expected to be positively associated with all indices of selective attentional processing of pain stimuli. Results were analyzed with repeated-measures analysis of variance. An incongruency effect was found for patients and to a significantly less degree for pain-free control subjects on the dot-probe task with pictorial stimuli, indicating that pain patients have difficulty disengaging from threat pictures. Pain-related fear as a trait measure (TSK) was not associated with selective attentional processing of word and pictorial stimuli in either pain patients or control subjects. Results from the present study are discussed, and directions for future research are provided.**
*Perspective: Demonstrating difficulty to disengage from threat might be clinically relevant because patients might pay less attention to fear-disconfirming information and remain engaged in avoidance, which might eventually lead to prolonged anxiety states.*
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*Key words: Selective attentional processing, chronic low back pain, dot-probe.*

The cognitive approach of psychopathology has mainly been inspired by the schema theory of Beck and Bower's network theory of the relation between cognition and emotion.[3-6] The investigation of distortions in information processing (eg, biases in attention, memory, and interpretation) in several emotional disorders such as anxiety disorders and depression has become a popular line of investigation since the early 1980s. Research has shown that biases in attention are particularly present in anxiety disorders.[30] Drawing on this research, researchers in the field of chronic pain have also become interested in assessing biases in attention in chronic pain patients as a function of anxiety or fear of pain.[20,29] In line with research in anxiety disorders, higher levels of pain-related fear are assumed to be associated with more severe biases in attention (ie, selective attentional processing of pain-related stimuli).

The visual dot-probe task has been developed as a more direct measure of selective attentional processing, which might serve as an alternative to the modified Stroop task.[19]

Generally, 2 types of word pairs are presented in a visual dot-probe task. The first type of word pairs consists of an emotional word and a neutral word. The second type of word pairs consists of 2 neutral words. The latter category of word pairs is used as filler stimuli. One word pair (either an emotional word and a neutral word or 2 neutral words) appears at the same time on a computer screen, one word above the other. One of these 2 words is then replaced by a small dot, and the location of the dot (upper or lower) has to be indicated. A conventional way to analyze dot-probe data has been the computation of a bias index, in which only word pairs consisting of emotional (pain) words and neutral words are taken into account. A positive score on this index is indicative of selective attentional processing, whereas a negative score reflects a bias away (eg, avoidance) from such material. In using the bias index, Asmundson et al[2] did not find evidence for selective attentional processing of sensory and affective pain words selected from the McGill Pain Questionnaire[18] in pain patients compared with pain-free control subjects. However, when pain patients were divided into 2 groups on the basis of their scores on a measure of anxiety sensitivity (ie, the proneness to experience fear in response to anxiety-related sensations), those with low anxiety sensitivity shifted attention away from pain words, whereas those with high anxiety sensitivity responded similarly to dot probe regardless of the location of presentation. Dehghani et al[8] found support for selective attentional processing of sensory pain

words in chronic pain patients but regardless of the level of fear. A shortcoming of this study was that it did not include a pain-free control group, so that it is unknown whether the observed bias is specific for pain patients. Drawing on the findings of Asmundson et al,[2] Keogh and colleagues conducted 4 dot-probe experiments in undergraduates. Although 2 dot-probe studies found evidence to suggest that pain-free individuals display selective attentional processing to pain-related words as a function of anxiety sensitivity[10] and fear of pain,[11] two other dot-probe studies of Keogh et al[12,13] as well as a dot-probe study by Roelofs et al[23] did not.

Recently, Koster et al[15] reported a dot-probe study that did take not only word pairs consisting of an emotional word and a neutral word but also word pairs containing 2 neutral words into analyses. The rationale behind the use of word pairs consisting of 2 neutral words was that these trials could serve as a control condition. Therefore, it is possible to compare response times of so-called experimental trials in which a dot replaces an emotional word (in emotional-neutral word pairs) with neutral control trials (in neutral-neutral word pairs) and to compare response times of experimental trials in which a dot replaces a neutral word (in emotional-neutral word pairs) with neutral control trials (in neutral-neutral word pairs). In the first comparison, a congruency effect (ie, emotional word is replaced by a dot) predicts faster response times on experimental trials compared with neutral control trials. In the latter comparison, an incongruency effect (ie, neutral word is replaced by a dot) predicts delayed response times on experimental trials compared with neutral control trials.

The present study sought to investigate to what extent patients with chronic low back pain (CLBP) and pain-free control subjects selectively attend to pain-related stimuli as measured with 3 indices of selective attentional processing: a bias index, a congruency effect, and an incongruency effect. This study is the first to administer 2 dot-probe tasks containing word stimuli and pictorial stimuli. For the bias index, CLBP patients were expected to respond faster to experimental trials in which a dot replaces pain words than experimental neutral words compared with pain-free control subjects. For the congruency effect, CLBP patients were expected to respond faster to experimental trials (ie, emotional word/picture is replaced by a dot) compared with neutral control trials than pain-free control subjects. For the incongruency effect, CLBP patients were expected to respond slower to experimental trials (ie, neutral word/picture is replaced by a dot) compared with neutral control trials than pain-free control subjects. Self-reported fear of movement and injury was expected to be positively associated with all 3 indices of selective attentional processing.

## Methods and Materials

### Participants

Forty-nine CLBP patients (mean age, 51.1 years; standard deviation [SD], 9.8; range, 29 to 64 years) and 44 pain-free control subjects (mean age, 45.6 years; SD, 13.0; range, 18 to 65 years) participated in the present study. Control subjects were recruited from local advertisements. CLBP patients were recruited from the pain clinic of the Maastricht University Hospital and via a Dutch patients' association for back pain patients. Inclusion criteria were (1) experiencing low back pain for at least 6 months and (2) age between 18 and 65 years. Exclusion criteria were (1) serious visual deficit and deafness, (2) being non-fluent in Dutch, (3) serious psychiatric diseases on the basis of self-report, and (4) alcohol and/or drug problems. The CLBP sample comprised 23 men and 26 women, and the sample of control subjects consisted of 18 men and 26 women. Current pain intensity was rated on a 100-mm visual analogue scale. Mean pain intensity at the time of testing of the CLBP sample was 60.1 mm (SD, 26.3), and pain intensity of the control subjects was 3.6 mm (SD, 8.6 mm). With respect to the level of disability, mean total score of the CLBP sample on the Quebec Back Pain Disability Scale[14] was 55.4 (SD, 17.5), indicating that this sample was substantially disabled. In addition, mean pain duration in the CLBP sample was 144 months (SD, 121 months; range, 18 to 420 months). All participants signed a written informed consent in which part of the experimental design was explained. Participants were unfamiliar with the hypothesis and the dot-probe tasks. Full debriefing took place immediately after the end of the experiment, and results from the experiment were sent by mail after completion of the study. The experimental protocol was approved by the Ethics Committee of the Maastricht University Hospital/Maastricht University.

### Materials

The first task was a dot-probe task in which words were used as stimuli. Six word groups were used: sensory pain (eg, cutting, burning), affective pain (eg, sickening, gnawing), injury (eg, hernia, paralyzed), movement (eg, bending, falling), social threat (eg, blushing, alone), and neutral words (words reflecting household goods). Sensory and affective pain words were included, because a meta-analysis has shown that these words are associated with selective attentional processing.[22] Injury- and movement-related words might tap specific aspects of fear of pain that are relevant for pain patients. Social threat words were included to examine whether a general negativity bias was present rather than a specific pain-related bias. All words were closely matched with a neutral word for the number of syllables, word length, and word frequency. The trial consisted of 5 sensory pain, affective pain, movement, and injury related words. In addition, 10 social threat and neutral words were used. Each word pair was presented 4 times (target upper or lower, dot upper or lower), producing a total number of $40 \times 4 = 160$ trials. A list of all word stimuli can be obtained from the first author.

The second dot-probe task included pictorial stimuli. All participants were shown a series of 96 pictures from the Photograph series of Daily Activities (PHODA)[16] and were asked to rate how threatening performance of the activity depicted on the picture would be for their back.

The 5 pictures evaluated with the highest level of back injury (target) and 5 with the lowest level of back injury (control) were selected for each individual. Thus, the pictorial stimuli were selected idiosyncratically. Each trial consisted of 2 pictures (target versus control) that were randomly combined for each individual. Each picture pair was presented 4 times (target upper or lower, dot upper or lower). Ten fillers were selected from the International Affective Picture System[17] on the basis of low arousal and neutral affect and were also presented 4 times each. Thus, a total number of 40 trials were administered to each participant. All pictures were resized to the same dimensions, 3 inches high × 3 inches wide.

After completing both tasks, all participants indicated their current pain intensity (during testing) on a 100-mm visual analogue scale and completed the Tampa Scale for Kinesiophobia (TSK) (Miller et al, unpublished data, 1991).[9,24] The TSK is a self-report measure of fear of movement and fear of (re)injury and has 17 items to be rated on a 4-point Likert scale. Anchors are labeled "strongly agree" and "strongly disagree."

### Procedure

In both visual dot-probe tasks, participants were initially presented with a fixation cross in the center of a 17-inch color monitor for 500 milliseconds. Two words/pictures were presented, one above and one below this fixation point. After an additional 500 milliseconds, a dot replaced either the upper or the lower word/picture. Participants were instructed to press the "q" key on the keyboard if the dot appeared in the upper position and the "z" key if it appeared in the lower position. The dot disappeared as soon as a response had been made or after 3000 milliseconds. The next trial began after 500 milliseconds. The order of both dot-probe tasks was counterbalanced, and both tasks were controlled by E-prime version 1.0 (Psychology Software Tools, Inc, Pittsburgh, PA). Each task lasted for approximately 6 minutes, and there was a break of 5 minutes between both tasks. For all patients, vision was normal at time of testing.

### Data Reduction, Hypotheses, and Statistical Analyses

For both dot-probe tasks, incorrect responses and outliers (defined as a reaction time deviating more than 3 standard deviations from each individual mean reaction time) were excluded. The bias index for both word stimuli and pictorial stimuli was computed according to the following formula: Bias index = [(eudl − eldl) + (eldu − eudu)]/2, where e = emotional word/picture, d = dot, u = upper, and l = lower position. For the dot-probe task with word stimuli, CLBP patients were hypothesized to have higher scores on the bias index compared with control subjects in particular for the various categories of pain words (but not for social threat words). A repeated-measures analysis of variance was performed with bias index (sensory pain, affective pain, movement, injury, and social threat) as the within-groups factor and group (patients versus control subjects) as the between-groups factor. An interaction between group and bias index was expected. For the dot-probe task with pictorial stimuli, a univariate analysis of variance was used to examine whether the magnitude of the bias index (dependent variable) differed between patients and control subjects. Thus, a main effect of group was expected.

The following formulas can be used to compute mean response times of experimental trials in which a dot replaces an emotional word [(eudu + eldl)/2] or a neutral word [(eudl + eldu)/2]. Neutral control trials are computed as follows: [(nudu + nudl + nldu + nldl)/4]. For these formulas, e = emotional word, n = neutral word, d = dot, u = upper, and l = lower position. Compared with pain-free control subjects, CLBP patients were hypothesized to show a stronger congruency effect as well as a stronger incongruency effect. It is important to note that a congruency effect and an incongruency effect are not mutually exclusive effects. Two successive repeated-measures analyses of variance were conducted with either word category or picture type as the within-groups factor and group (patients versus control subjects) as the between-groups factor. We expected interactions between group and the congruency effect and between group and the incongruency effect.

After this, the effects of fear of movement and injury (TSK) on the bias index, the congruency effect, and the incongruency effect in both dot-probe tasks were examined. It should be noted that mean TSK scores of patients were substantially higher compared with control subjects, and the normal distributions of TSK scores from patients and control subjects showed only a limited overlap. Consequently, effects of pain-related fear (TSK) were analyzed in patients and control subjects separately by means of analysis of variance. TSK scores were entered in the analyses as a continuous covariate. For the bias index of the dot-probe task with word stimuli, a positive association between TSK scores and the various categories of pain words was hypothesized, but no such association was expected for social threat words. Thus, an interaction between TSK and word category was expected. For the dot-probe task containing pictorial stimuli, TSK scores were hypothesized to show a positive association with the bias index. For the congruency effect and incongruency effect, positive associations between TSK scores and the congruency effect and incongruency effect, respectively, were expected. The impact of fear of movement and injury on the indices of selective attentional processing was predicted to be most strongly present in CLBP patients. For all analyses, alpha was adjusted to .01 to prevent spurious findings as a result of multiple testing.

## Results

Before addressing the main results of the study, one remark has to be made. Because of technical problems with the dot-probe task with words, 31 CLBP patients and 40 control subjects actually completed this task. A total number of 49 CLBP patients and 42 control subjects participated in the dot-probe task with pictures. Table 1

## Table 1. Descriptive Statistics of the Questionnaires and Bias Indices

| | CLBP Patients | | Control Subjects | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| TSK | 40.1 | 10.0 | 31.2 | 6.0 |
| Bias index sensory words | 13.1 | 68.8 | −8.2 | 45.8 |
| Bias index affective words | −2.0 | 57.0 | 5.3 | 40.6 |
| Bias index injury words | 4.6 | 50.3 | −7.7 | 55.8 |
| Bias index movement words | 4.4 | 69.1 | −0.3 | 56.7 |
| Bias index social words | 11.5 | 39.0 | 6.1 | 25.9 |
| Bias index pictures | 10.2 | 69.2 | 7.9 | 45.5 |

Abbreviations: CLBP, chronic low back pain; SD, standard deviation; TSK, Tampa Scale for Kinesiophobia.

depicts descriptive statistics of the TSK and mean response times for the bias indices (both words and pictures). It should be noted that mean scores on the bias indices were small and have relatively large SDs. After removing missing values and outliers, mean response times of experimental trials and neutral control trials were computed for all word categories as well as for the pictorial dot-probe (Table 2). All variables presented in Table 2 were normally distributed. As can be seen in Table 2, response times to pictorial stimuli were generally slower compared with response times of word stimuli in both CLBP patients and control subjects. The main results are presented below for each dot-probe task separately.

### Dot-Probe Task With Words

For the analysis with the bias index, the expected interaction between group and the bias index ($F_{4,66} = .56$; $P =$ .69; $\eta^2 = .03$) was nonsignificant. For the congruency effect, no significant interaction was found between group and the congruency effect as reflected by the difference of response times of experimental trials (ie, dot replaces emotional word) and neutral control trials ($F_{5,66} = .63$; $P = .63$; $\eta^2 = .05$). For the analysis of the incongruency effect, the expected interaction between group and the incongruency effect as reflected by the difference of response times of experimental trials (ie, dot replaces neutral word) and neutral control words was nonsignificant ($F_{5,66} = 1.12$; $P = .36$; $\eta^2 = .08$).

### Dot-Probe Task With Pictures

Mean ratings of PHODA pictures that were selected as the least threatening were rated 3.8 (SD, 5.5) by control subjects and 9.1 (SD, 14.2) by CLBP patients on a scale of 0 to 100. Ratings of pictures that were selected as most threatening were 60.7 (SD, 34.3) for control subjects and 77.5 (SD, 26.3) for CLBP patients. A repeated-measures analysis of variance with picture category (high versus low threat) as within-subjects factor and group (patients versus control subjects) as between-subjects factor showed a significant effect of picture category ($F_{1,91} = 452.0$; $P < .001$; $\eta^2 = .83$) and a significant main effect of group ($F_{1,91} = 8.90$; $P = .004$; $\eta^2 = .09$), indicating that low threat pictures were scored as significantly less threatening than high threat pictures and that CLBP patients scored all activities as more threatening for the back than control participants.

For the analysis with the bias index, the expected main effect of group was nonsignificant ($F_{1,89} = .03$; $P = .85$; $\eta^2 = .01$). For the analysis of the congruency effect, the interaction between group and the congruency effect reflected by the difference of response times of experimental trials (ie, dot replaces emotional picture) and

## Table 2. Response Times (in Milliseconds) of Congruent, Incongruent, and Neutral Trials for CLBP Patients and Control Subjects

| | Congruent Trials, Mean (SD) | Incongruent Trials, Mean (SD) | Neutral Trials, Mean (SD) |
|---|---|---|---|
| CLBP patients | | | |
| Sensory words | 662 (123) | 676 (132) | — |
| Affective words | 659 (126) | 660 (124) | — |
| Injury words | 671 (139) | 678 (142) | — |
| Movement words | 647 (124) | 653 (125) | — |
| Social words | 658 (127) | 670 (133) | — |
| Pictures | 746 (154) | 742 (163) | — |
| Neutral words | — | — | 659 (119) |
| Neutral pictures | — | — | 705 (146) |
| Control subjects | | | |
| Sensory words | 573 (125) | 577 (113) | — |
| Affective words | 575 (129) | 580 (129) | — |
| Injury words | 578 (135) | 570 (130) | — |
| Movement words | 574 (132) | 573 (133) | — |
| Social words | 576 (126) | 582 (127) | — |
| Pictures | 705 (146) | 665 (164) | — |
| Neutral words | — | — | 572 (129) |
| Neutral pictures | — | — | 637 (150) |

Abbreviation: CLBP, chronic low back pain.

neutral control trials was nonsignificant ($F_{1,90} = 4.22$; $P = .043$; $\eta^2 = .05$). For the incongruency effect, the interaction between group and the incongruency effect as reflected by the difference of response times of experimental trials (ie, dot replaces neutral word) and neutral control trials was significant ($F_{1,90} = 8.05$; $P = .006$; $\eta^2 = .08$). In clarifying this interaction, both CLBP patients and pain-free control subjects exhibited delayed response times on experimental trials compared with neutral control trials, but the difference between these delayed response times was significantly greater for CLBP patients (Table 2).

### Impact of Fear of Movement and Injury

For the dot-probe task with word stimuli, no significant interaction was found between fear of movement and injury (TSK) and the indices of selective attentional processing (ie, bias index, congruency effect, incongruency effect) in accounting for response times in either CLBP patients or pain-free control subjects ($P$ values > .06). For the dot-probe task with pictorial stimuli, no main effect of fear of movement and injury (TSK) was found on the bias index for either CLBP patients or pain-free control subjects ($P$ values > .59). The interactions between fear of movement and injury (TSK) and the congruency and incongruency effects were not significant in either CLBP patients or pain-free control subjects.

## Discussion

The present study sought to investigate to what extent CLBP patients and pain-free control subjects selectively attend to pain-related stimuli, and this study is the first to include 2 dot-probe tasks containing word stimuli and pictorial stimuli. This study is also unique in the way results were analyzed. Three indices of selective attentional processing were used in the present study: the conventional bias index, a congruency effect, and an incongruency effect. The effect of fear of movement and injury as measured with the TSK on these indices of selective attentional processing was examined for patients and control subjects separately.

Results showed that CLBP patients, and to a significantly lesser degree control subjects, displayed an incongruency effect indicating that CLBP patients experienced more difficulty than pain-free control subjects in disengaging from threat as measured with a visual dot-probe task containing pictorial stimuli. These results are in line with and extend the results obtained in a previous study that examined congruency and incongruency effects toward highly threatening, mildly threatening, and neutral pictures selected from the International Affective Picture System[17] in healthy undergraduates.[15] Results from that study found support for an incongruency effect indicating difficulty to disengage from threat pictures but could not also provide evidence for a congruency effect. The observation that control subjects also experienced difficulty to disengage might be due to the fact that control subjects also had some concerns regarding movement and injury as reflected by the ratings of the threatening pictures by control subjects. Recently, an alternative paradigm for studying difficulty to disengage from threat has been developed.[28] In this so-called cueing paradigm, pain targets and tone targets had to be detected as quickly and as accurately as possible. The target stimuli were preceded by pain cues, tone cues, or neutral cues. When pain was cued and did not occur, there was retardation in disengagement from the pain cue. This retardation was particularly present in individuals high in catastrophic thinking.[28] Thus, 2 different paradigms (dot-probe and cueing paradigms) have now provided evidence that selective attentional processing is accounted for by difficulty to disengage from threat rather than vigilance to threat. However, there is no consistent evidence of the effects of pain-related fear and catastrophizing on the difficulty to disengage from threat. No support was found for selective attentional processing on the other indices. Furthermore, no effect of self-reported fear of movement and injury on the indices of selective attentional processing was found in either CLBP patients or pain-free control subjects.

There are some limitations of the present study that should be mentioned. First, we did not assess whether patients were on their usual pain medication or whether they used caffeine on the day of testing. Therefore, we cannot rule out any general retardation of response times in both dot-probe tasks caused by the use of pain medication or speedup of response times caused by the use of caffeine.[7] Second, because of technical problems only 31 patients completed the dot-probe task with word stimuli, whereas 49 patients completed the dot-probe task with pictorial stimuli. Consequently, the power for the analysis of data from both tasks is not comparable. However, it is unlikely that the pattern of results would have changed in the direction of significance when all patients would have completed this task. Third, the utility of the bias index as a measure of selective attentional processing might be limited because there is a large amount of variability in the bias indices, which might be an impediment to detect significant effects. Finally, the failure to find support for selective attentional processing on different categories of pain words might be due to the fact that word stimuli were not chosen idiosyncratically as was the case with pictorial stimuli. The importance of using idiosyncratically chosen stimuli has also been stressed by Riemann and McNally,[21] who found selective attentional processing on words that captured participants' current concerns on a modified Stroop task (an alternative measure to examine selective attentional processing). The concept of current concerns has also received some attention in the pain literature. Andersson and Haldrup[1] used personalized pain words in a modified Stroop task, but they failed to find conclusive evidence for selective attentional processing of these words in pain patients. In a yet unpublished study, our research group was also unable to find selective attentional processing in CLBP patients of pain words that captured current concerns. Thus, it seems that the current concerns issue has not been fully elucidated in the field of chronic pain. In this context, it might be

suggested that word stimuli might not be able to capture current concerns in CLBP patients because they are semantic representations of the feared stimuli. Pictorial stimuli that represent fear of movement and injury might be more salient and might therefore represent current concerns in patients because these stimuli directly visualize the feared stimuli. In this respect, it should be kept in mind that whether word stimuli in a dot-probe task are considered as threatening depends on the patient's experiences in the past, and that testing patients in a laboratory situation rather than in "real life" might also undermine the potential threat value of word stimuli. It might be that pictorial stimuli more closely reflect threatening situations in daily life and are therefore more suitable for use in a dot-probe task.

Taken together, previous dot-probe studies conducted in the field of chronic pain have provided limited evidence for selective attentional processing of threat stimuli in fearful pain patients. The present study examined different attentional components such as congruency and incongruency effects in addition to the bias index, because they might be considered as more sensitive and robust indicators of selective attentional processing than the conventional bias index. The present study was also the first to examine selective attentional processing on 2 dot-probe tasks with word stimuli and pictorial stimuli. Support for an incongruency effect on pictorial stimuli was found, suggesting that CLBP patients experienced difficulty to disengage from threat pictures to a greater extent than pain-free control subjects. With respect to the clinical relevance of the findings, Koster et al[15]

pointed out that patients might give limited attention to fear-disconfirming information, active coping strategies, and that feelings of uncontrollability might develop from the experience of being unable to shift attention away from threat, eventually leading to prolonged anxiety states. Future research should be aimed at further examining to what extent pain patients display selective attentional processing as tapped by specific attentional components such as congruency and incongruency effects. However, our study could not find a relation between fear of movement and injury and the tendency to experience difficulty disengaging from threat stimuli. Perhaps pain catastrophizing might be more strongly associated with difficulty to disengage from threat stimuli than fear of movement and injury.[15] In particular, rumination as tapped by a subscale of the Pain Catastrophizing Scale,[25,27] defined as a tendency to focus excessively on pain sensations, might show the strongest association with difficulty to disengage from threat. Because rumination has been shown to be a substantial predictor of pain-related disability,[26] it is important to establish the various ways in which rumination might influence pain-related disability.

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