

THE PREDICTIVE VALUE OF ATTENTIONAL BIAS TOWARDS PAIN-
RELATED INFORMATION IN CHRONIC PAIN PATIENTS: A DIARY STUDY

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INTRODUCTION

The preferential and selective processing of threatening information, i.e., an attentional bias, is an ubiquitous phenomenon in phobia and anxiety disorders (for a review see [3]). Adopting theories and paradigms from the anxiety literature, researchers have investigated whether chronic pain patients also selectively attend to pain-related information. Although results are not always consistent, chronic pain patients are often found to have an attentional bias towards pain-related information in comparison with healthy volunteers [38,43,46].

An important question pertains to the precise function of an attentional bias towards pain-related information. Whereas an attentional bias towards pain-related information is argued to be initially adaptive because it allows to escape or avoid pain, a persistent attentional bias when pain cannot be avoided or escaped from -which is mostly the case when it is chronic - may only fuel pain, disability and distress [13,16,65]. In that respect, attentional bias has been considered as a maintaining or exacerbating factor in chronic pain [28]. Recent theoretical advances furthermore suggest that attentional bias may not directly amplify the experience of pain, but that (severe) pain may result in more avoidance behaviour, disability and distractibility of ongoing behaviour in those who have an attentional bias towards pain-related information [13]. Empirical research investigating this idea is, however, lacking. Available studies (e.g., [2,15,45]) investigating the relationship between attentional bias and pain outcomes in chronic pain patients are mainly cross-sectional. It therefore remains possible that attentional bias towards pain-related information is merely an epiphenomenon of chronic pain [28]. The few studies that explored the predictive value of attentional bias towards pain-related information are restricted to

predicting experimental pain sensitivity in healthy volunteers [5,6] and predicting post-operative pain in people undergoing a painful medical procedure [25,26,35]. Results are inconsistent, but suggest that a larger attentional bias towards pain-related information predicts higher pain sensitivity [5, but see 6] and less post-operative pain [25,35]. A more direct examination of the relationship between attentional bias and pain outcomes in chronic pain patients is warranted.

The current study aimed to further substantiate the predictive value of attentional bias towards pain-related information for pain outcomes in chronic pain patients. We focused upon four outcomes, i.e., pain severity, disability, avoidance behaviour and distractibility, which were assessed daily for a period of two weeks. Electronic diary assessment was preceded by a laboratory session during which questionnaires were filled out and attentional bias for pain-related information was assessed by means of a modified spatial cueing paradigm in which cues signalling experimental pain stimuli were presented [57].

In particular, we examined (1) the relationships between individual differences and attentional bias towards pain-related information, (2) whether attentional bias towards pain-related information has predictive value for the levels of daily pain severity, avoidance behaviour, disability and distractibility, and (3) whether attentional bias towards pain-related information moderates the relationship between daily reported pain severity and other pain outcomes.

METHOD

Participants

In December 2010, members of the Flemish Pain League (about 3000) were sent an invitation letter to participate in a large diary study for chronic pain patients, called the Ghent Pain and Disability I study (GPD-I study). The GPD-I

study consisted of one laboratory session in which participants were interviewed, filled out additional questionnaires and performed several experimental tasks. Subsequently, participants filled out a diary for 14 days. More information and specific details about this study can be found on <http://hdl.handle.net/1854/LU-3050986>. Five-hundred and eighteen patients responded to the letter, of which 315 agreed to be contacted by phone. Recruitment of participants was performed in the period February-March 2011. Two hundred sixty-seven persons were actually contacted by telephone. Inclusion criteria for the GPD-I study were: (1) being aged between 18 and 65 years; (2) having sufficient knowledge of the Dutch language; and (3) suffering from pain that lasted for six months or more. Individuals were excluded when headache pain was the most important pain (cfr. [17]) ($n = 1$), when they were unable to use both index fingers ($n = 1$) or when their eyesight was not normal or corrected-to-normal (e.g., by glasses) ($n = 2$). Eighty-one patients who fulfilled the criteria agreed to participate. Because participants needed to travel to the university campus to participate in this study, transportation problems were mentioned as the most frequent reason for non-participation. However, later on, a further seven patients decided not to participate because of health problems. The final sample of participants consisted of 74 individuals with chronic pain. The study design was approved by the Ethics Committee of the Faculty of Psychology and Educational Sciences of Ghent University, and written informed consent was obtained from participants. All participants received a monetary reward for their participation in the GPD-I study.

Questionnaires

State and trait anxiety were assessed by means of the Dutch version of the State-Trait Anxiety Inventory (STAI) [50,63]. This questionnaire consists of 40 items in which people are asked to report their feelings in general (e.g., I feel

happy) and at present (e.g., I feel upset) using a 4-point Likert scale. Scores for the state and the trait version may vary between 20 and 80. This questionnaire showed a good reliability and validity [4,51]. In the present study, Cronbach's alpha of the STAI-S (STAI state version) and STAI-T (STAI trait version) were respectively .91 and .93. *Disability* because of pain was assessed by means of the Dutch version of the Pain Disability Index (PDI; [39]). Participants are asked to indicate the extent of disability experienced in seven areas of everyday life (e.g., family/ home responsibilities and social activity) using a 0–10 Likert scale (0 = no disability and 10 = total disability). Scores may vary between 0 and 70. In the present study Cronbach's alpha of the PDI was .82. *Depressive mood* was measured with the depression subscale of the Hospital Anxiety and Depression Scale (HADS-D; [66]). The HADS-D is a self-report scale that screens for the presence of depression in patients with “medical conditions”. It consists of seven items to be rated on a 4-point Likert scale (e.g., I feel cheerful). Scores may vary between 0 and 21. In the present study Cronbach's alpha of the HADS-D was .82. *Pain severity* was assessed by means of the pain severity subscale of the Multidimensional Pain Inventory (MPI; [22,29]). Part I of the MPI consists of five subscales assessing the impact of pain (e.g., pain severity, pain interference, and affective distress). The reliability and validity of the MPI have been well established [44]. In the present study Cronbach's alpha of the MPI severity subscale was .75. *Catastrophic thinking* about pain was assessed with the Dutch version of the Pain Catastrophizing Scale (PCS), which consists of 13 items [11,52]. Participants indicate the degree to which they experienced catastrophic thoughts or feelings during pain episodes (e.g., “I become afraid that the pain will get worse”) using a 5-point scale. Scores may vary between 0 and 52. This scale showed a good reliability and validity [54]. In the present study, Cronbach's alpha

of the total score was .90.

Attentional bias towards pain-related information

Attentional bias towards pain-related information was assessed using a modified spatial cueing task [57,58,59,62]. For this task participants needed to discriminate a visual target (i.e., : or "), which was preceded by coloured cues (pink or blue square; 4.8 cm high × 6.5 cm wide) at the same (valid) or opposite (invalid) spatial location. Each trial began with a fixation cross in the middle of the screen (duration of 1000 ms). Cues were presented 9.2 degrees from the fixation cross for a duration of 200 ms. Target onset followed immediately after cue offset. On two third of the test trials, cue target location was correctly predicted by cue location (validly cued trials). On one third of the test trials, cue location incorrectly predicted target location (invalidly cued trials). Participants were instructed to respond to the horizontal dots by pressing the '4' key with the index finger and to the vertical dots by pressing the '5' key with the ring finger of the right hand on a AZERTY computer keyboard. A trial ended when a participant responded or 2000 ms had elapsed. A 1000 ms interval was given before the next trial was presented. In order to control for responses to cues instead of targets, a number of trials were presented, in which the cue was not followed by a target (catch trials). Furthermore, in order to ensure that participants maintained gaze at the middle of the screen, a number of digit trials were presented. In these trials, the fixation cross was followed by a randomly selected digit between one and nine for a duration of 100 ms (digit trials). Participants were instructed to type the number on the keyboard. Cues were presented in two colours. One colour was related to pain by a differential classical conditioning procedure. The conditioned cue (CS+) was on one third of the presentations followed by a painful stimulus (unconditioned stimulus; UCS; 500 ms after CS+ onset), i.e., an

electrocutaneous stimulus (ECS; bipolar; 50 Hz; 300 ms; instantaneous rise and fall time delivered by a constant current stimulator, i.e., DS5, Digitimer Ltd, Hertfordshire, UK). The other colour (CS–) was never followed by an UCS. Which colour was CS+ or CS– was counterbalanced across participants. The CS+ and CS– were presented equally often and in a random order. The task started with a practice phase during which no pain stimuli were administered. This was followed by an acquisition phase during which the CS+ was always followed by an ECS (four trials: 2 CS+ trials, 2 CS- trials). After this phase participants were asked to indicate which colour was related to the ECS. When they gave an incorrect answer, they needed to repeat the acquisition phase. When they answered this question correctly, they started the test phase. The test phase consisted of 188 trials: 96 validly cued trials, 48 invalidly cued trials, 32 catch trials, and 12 digit trials. Overall, it is expected that participants are faster on valid than on invalid trials, a phenomenon called the cue validity effect. It is assumed that when participants' attention is biased towards pain-related cues, the cue validity effect should be larger on CS+ trials than on CS- trials.

Electronic diary assessment

Participants were asked to fill out an online diary at the end of each day for two weeks. Participants were reminded to fill out the diary each day at 7PM by means of a text message. The diary took approximately five minutes to complete. In this study only a part of the items are described, because only these items are of relevance for the current research aim¹. All items were rated on a 11-point Likert scale. Pain severity was assessed by means of aggregating the score of two items, i.e., 'On the average, how severe has your pain been today' (0 = "no pain" – 10 = "worst imaginable pain") and 'Which number would you ascribe to

¹ All diary items can be received from the authors upon request

the pain you experienced today the most' (0 = "no pain" – 10 = "worst imaginable pain"). Avoidance behaviour was assessed by means of the item 'To what extent did you avoid activities because of pain?' (0 = "not at all" – 10 = "very much"). Disability was assessed by means of the item 'To what extent did pain hinder you in your planned activities?' (0 = "not at all" – 10 = "very much"). Distractibility was assessed by means of the item 'To what extent were you distracted?' (0 = "not at all" – 10 = "very much").

Procedure

The study consisted of three phases. In Phase 1, participants filled out online questionnaires (i.e., PCS, PDI, MPI, STAI-T, HADS) and demographic information. In Phase 2, attentional bias towards pain-related information was assessed in the laboratory. The modified spatial cueing task was the first task participants performed of several tasks that were required to perform in the context of a larger study (GPD-I-study; see above). At the start of this study participants received general practical information (e.g., duration, break,...) and signed informed consent. Before starting the modified spatial cueing task participants received the following information "*This task is a computer task. During this task pain stimuli will be administered that directly stimulate the pain nerve. Before the experiment starts you will become familiar with these pain stimuli*". Next the wrist of the left arm of the participants was scrubbed and two lubricated Technomed Europe surface electrodes (Maastricht, The Netherlands; 1 cm diameter) were attached at the location of the distal radio-ulnar articulation on the wrist of the left arm. Afterwards participants were familiarised with the ECS by the administration of ECS of increasing intensity. The intensity of the stimulus started at 0.5 mA and increased in steps of 0.5 mA until 3 mA was reached. The 3 mA stimulus was then used during the experiment. If participants, however

reached their tolerance level before a maximum of 3 mA was reached ($N = 9$), this stimulus intensity was used during the task. A maximum limit of the ECS was included to increase individual variation, rather than to optimize the chance to find an attentional bias by using pain stimuli at tolerance level for all participants [10]. The mean intensity level was 2.80 mA ($SD = 0.58$). The pain stimulus was experienced as moderately intense ($M = 5.59$, $SD = 2.27$; range 0-10) and unpleasant ($M = 5.38$, $SD = 2.61$; range 0-10). An UCS pain rating was calculated by averaging between pain intensity rating and pain unpleasantness rating ($M = 5.48$, $SD = 2.33$; range 0-10). This was followed by the STAI-S. The performance of the modified spatial cueing paradigm was then followed by a manipulation check. Participants rated the extent to which they expected that an ECS would be administered following each cue (CS+ or CS-) as well as their fear at the moment of seeing each cue on a 11-point numerical rating scale (anchored respectively 0 = 'not at all' and 10 = 'very strongly'; 0 = 'not afraid' and 10 = 'very afraid'). In Phase 3, which started two days after the lab session, participants filled out the online diary for two weeks.

Data handling

Participants' diary reports were only included in the analyses if they filled out the diary for at least two thirds of the days. Based on this criterion, four participants were removed from the final analyses. Furthermore, one participant stopped the modified spatial cueing paradigm because he perceived the pain stimulus at the lowest level as too painful. A total of 69 participants were included in the final analyses.

Next the data of the modified spatial cueing paradigm were trimmed. Trials during which an ECS was applied were removed from further analyses. In these trials, response times could be affected by both the CS+ and the UCS,

because there was a temporal overlap between the presentation of the UCS and the response to the target. As we were interested in the pure effect of the CS+, we omitted these trials from the analyses [57]. Also trials with errors (< 4%) and responses faster than 150 ms and slower than 3 *SD* above the individual mean reaction time of correct responses were removed from further analyses (< 2%).

Analytic plan

Descriptive statistics and correlation analyses were performed with SPSS statistical software, version 15.0 for Windows (SPSS Inc., Chicago, IL). Because the multiple daily observations are nested within participants, we conducted multilevel regression analyses using the HLM software package (Version 7.01) to test the hypotheses [41]. Because of the hierarchical structure in the dataset the variability in outcome measures can be constructed with a Level 1 model, representing sources of within-person variability, and a Level 2 model, representing sources of between-person variability. In our study, Level 1 variables consisted of the multiple daily observations, and Level 2 variables consisted of between-person variables, e.g., gender, age, pain duration, pain severity and attentional bias towards pain-related information as measured by the modified spatial cueing task. Level 1 variables were group mean centred. Continuous Level 2 variables were grand mean centred. The Level 2 variable gender was dummy coded (0 = females; 1 = males) and entered into the equations as uncentred [36]. All continuous Level 1 and Level 2 variables were standardized for ease of interpretation of coefficients. Full maximum likelihood estimation was used for all models. In our analyses we followed a model building procedure [41]. When effects of control variables proved to be non-significant, we excluded them from further steps in model building to maximize stability and reliability of the findings [24]. The moderator role of attentional bias towards pain-

related information was investigated in the last step of model building. Models included random intercepts and random slopes. Effect sizes r were calculated according to the formula provided by Kenny and colleagues [21], with $r > .10$ indicating a small effect, $r > .30$ indicating a medium effect, and $r > .50$ indicating a large effect [8].

RESULTS

Participant characteristics

The mean age of the participants was 49.64 years ($SD = 9.82$; range 22-64 years) and 46 were female (67%). A majority of the participants were married (62.3%) or living together (10.1%). A total of 43.3% of the participants reported a higher education level (university or college degree), 55.2% of the participants quitted school after reaching a secondary education degree and the remainder quitted school after reaching a primary education degree (1.5%). On average, the duration of pain was 170.74 months ($SD = 111.58$) and participants reported a mean disability level of 39.20 ($SD = 11.42$) on the PDI. Furthermore, participants reported a mean pain level of 3.86 on the MPI ($SD = 0.98$). Mean scores for state and trait anxiety were comparable with those in other chronic pain studies (respectively $M = 38.27$, $SD = 9.49$ and $M = 47.20$, $SD = 11.43$) [2,12]. Almost all participants reported more than one pain location ($M = 3.86$, $SD = 1.87$; range = 1-9). Most reported were back pain (92.8%), neck pain (68.1%), leg pain (66.7%) and arm pain (44.9%). Depression scores were mildly elevated ($M = 8.39$, $SD = 4.06$) in comparison with available norms [49] (see Table 1 for an overview).

Modified spatial cueing task

Ratings indicated that the experimental manipulation was successful. Participants reported more fear of the CS+ cue ($M = 2.62$, $SD = 2.91$) compared

to the CS- cue ($M = 0.90$, $SD = 1.45$; $t(67) = 5.71$, $p < .001$) and expected to experience an ECS after the CS+ cue ($M = 4.88$, $SD = 3.18$) more often than after the CS- cue ($M = 1.04$, $SD = 1.68$; $t(67) = 9.43$, $p < .001$). Next, a 2 (Cue Validity: Valid vs. Invalid) x 2 (Signal: CS- vs. CS+) repeated measures ANOVA was performed. Results showed a main effect of Cue Validity ($F(1,68) = 96.55$, $p < .001$), indicating that participants were significantly faster on valid trials ($M = 732$ ms, $SD = 116$), than on invalid trials ($M = 788$ ms, $SD = 136$). No main effect of Signal was found ($F < 1.74$, ns). The critical Cue Validity x Signal interaction effect was not significant ($F < 1.09$, ns). Note, however, that the absence of this overall effect was not entirely unexpected given the fact that a maximum intensity of 3 mA was used to avoid ceiling effects in attentional bias and thus to maximize meaningful interindividual differences in attentional bias effect. To further investigate the role of attentional bias, an attentional bias index was calculated by subtracting the difference of invalid and valid CS- trials from the difference of invalid and valid CS+ trials ($M = 7.58$, $SD = 60.26$). The odd-even split half-reliability of the attentional bias index was low ($r = .00$).

Correlational analyses

Correlational analyses were performed between the attentional bias index and other individual difference measures (i.e., pain duration, catastrophic thinking, state anxiety, trait anxiety, depression, disability, pain severity) to determine whether these individual differences were related to the attentional bias index. Results showed that disability and pain severity positively correlated with the attentional bias index, indicating that chronic pain patients who are more disabled and report more severe pain are also more biased towards pain-related information (see Table 1).

-INSERT TABLE 1-

Multilevel analyses

Pain severity

Initial analyses indicated that there was substantial variance in reported pain severity within participants (38%), and also between participants (62%). Next, we included attentional bias towards pain-related information as a between-subject variable. No Level 1 variables were included. Although the model proved not to be significantly better than a model including no predictors, $\chi^2(1) = 2.52$, $p = .11$, attentional bias was a significant predictor of daily pain severity (Coefficient = .31, $t(67) = 2.07$, $p < .05$) and accounted for 4% of the between-person variance. Second, we added additional between-person variables, i.e., UCS pain rating, age, gender, pain severity at baseline and pain duration in our model as control variables. The proposed model proved to be better than a model that did not include predictors ($\chi^2(6) = 29.43$, $p < .001$) and the model with attentional bias towards pain-related information as single predictor ($\chi^2(5) = 26.92$, $p < .001$). The Level 2 variables accounted for 36% of the between-person variance. When controlling for these additional variables, the unique variance that could be explained on the basis of attentional bias towards pain-related information was no longer significant. Two other predictors were, however, significant. First, participants who reported more severe pain at baseline reported more daily pain severity (Coefficient = 0.73, $t(62) = 4.66$, $p < .001$). Second, participants who rated the UCS as more painful reported more daily pain severity (Coefficient = 0.39, $t(62) = 2.47$, $p < .05$). The variables age, gender and pain duration were excluded from the final model because they were not significant (see Table 2).

Avoidance behaviour

Initial analyses indicated that there was substantial variance in reported avoidance within participants (56%), and also between participants (44%). First, we investigated whether daily pain severity (Level 1 variable) was associated with reported avoidance. This model proved to better explain the data than a model including no variables, $\chi^2(3) = 203.90$, $p < .001$. About 19% of the within-person variance in avoidance was explained by daily pain severity (Coefficient = 1.52, $t(68) = 10.94$, $p < .001$), indicating that participants reported more avoidance on days that pain was more severe.

Second, we included the between-person variables, i.e., attentional bias towards pain-related information, UCS pain rating, age, gender, pain severity at baseline and pain duration in our model to investigate whether these between-person variables affected pain avoidance. This model proved to be better than a model including only the Level 1 variable, $\chi^2(6) = 16.71$, $p < .05$. The Level 2 variables accounted for 24% of the between-person variance. Analyses revealed that participants reporting more severe pain at baseline, showed more daily avoidance behaviour (Coefficient = 0.80, $t(62) = 3.66$, $p < .001$). Because the effects of age, UCS pain rating, gender, and pain duration were not significant, they were dropped from the final model.

Third, we entered attentional bias towards pain-related information as a cross-level moderator of the Level 1 relationship between daily pain severity and daily avoidance. The results for this model, however, did not indicate that attentional bias towards pain-related information moderated the relationship between daily pain severity and daily avoidance (Coefficient = 0.20, $t(67) = 1.23$, ns). Results of the final model are summarized in Table 2.

Disability

Analyses indicated that there was substantial variance in disability within participants (56%) and between participants (44%). First, we investigated whether daily pain severity (Level 1 variable) was related to daily disability. This model proved to be a better explanation of the data than a model including no variables, $\chi^2(3) = 358.79$, $p < .001$. About 33% of the variance was explained by daily pain severity (Coefficient = 1.85, $t(68) = 18.01$, $p < .001$), indicating that participants reported to be more disabled on days that pain was more severe.

Second, we included the between-person variables attentional bias towards pain-related information, UCS pain rating, age, gender, pain severity at baseline, disability at baseline and pain duration in our model to investigate whether these between-person variables affected daily disability. This model proved to be better than a model including only the Level 1 variable, $\chi^2(7) = 20.48$, $p < .001$. The Level 2 variables accounted for 26% of the between-person variance. Analyses revealed that participants reporting more severe pain at baseline, showed more daily disability (Coefficient = 0.63, $t(61) = 2.69$, $p < .001$). Because of the non-significant effects of UCS pain rating, age, gender, disability at baseline and pain duration, they were dropped from the final model.

Third, we entered attentional bias towards pain-related information as a cross-level moderator of the Level 1 relationship between daily pain severity and daily disability. This model proved to be better than a model including only the Level 1 and Level 2 variables, $\chi^2(1) = 3.86$, $p < .05$. Analyses revealed that the relationship between daily measured pain severity and disability was moderated by participants' level of attentional bias towards pain-related information. (Coefficient = 0.19, $t(67) = 2.05$, $p < .05$). This result indicates that the significant positive relationship within persons between daily pain severity and daily disability was stronger for chronic pain patients with a stronger attentional bias

towards pain-related information. Results of the final model are summarized in Table 2.

Distractibility

The analyses indicated that there was substantial variance in distractibility within participants (46%), and between participants (54%). First, we investigated whether daily pain severity (Level 1 variable) was associated with the daily level of distractibility. This model proved to be a better explanation of the data than a model including no variables, $\chi^2(3) = 68.17, p < .001$. About 4% of the variance was explained by daily pain severity (Coefficient = 0.72, $t(68) = 5.35, p < .001$), indicating that participants reported to be more distracted on days that pain was more severe.

Second, we included the between-person variables attentional bias towards pain-related information, UCS pain rating, age, gender, pain severity at baseline and pain duration in our model to investigate whether these between-person variables affected daily distractibility. This model proved to be better than a model including only the Level 1 variable, $\chi^2(6) = 13.32, p < .05$. The Level 2 variables accounted for 20% of the between-person variance. Analyses revealed that when participants reported more severe pain at baseline, they reported a higher level of daily distraction (Coefficient = 0.69, $t(62) = 3.04, p < .001$). Because the effects of age, UCS pain rating, gender, and pain duration were not significant, they were dropped from the final model.

Third, we entered attentional bias as a cross-level moderator of the Level 1 relationship between daily pain severity and daily distractibility. This model proved to be better than a model including only the Level 1 and Level 2 variables, $\chi^2(1) = 9.38, p < .01$. Analyses revealed that the relationship between daily measured pain severity and distractibility was moderated by participants' level of

attentional bias towards pain-related information (Coefficient = .38, $t(67) = 3.58$, $p < .001$). This result indicates that the significant positive relationship between daily pain severity and daily distractibility was stronger for chronic pain patients with a pronounced attentional bias towards pain-related information. Results of the final model are summarized in Table 2.

-INSERT TABLE 2-

DISCUSSION

The aim of this study was to investigate the predictive value of attentional bias towards pain-related information for daily measured pain outcomes in patients with chronic pain. Results can be readily summarised. First, attentional bias towards pain-related information was related to current disability and current pain severity in chronic pain patients. Furthermore, although attentional bias towards pain-related information was predictive for daily pain severity, this effect disappeared after adding control variables. Finally, results indicate that the more attention was biased towards pain-related information, the stronger the relationship was between (1) daily pain severity and disability and (2) daily pain severity and distractibility. Each of these findings deserves further exploration.

First, we found attentional bias to be related to higher pain severity and more disability. This finding is in line with our expectations and previous cross-sectional research [7,31, but see 2]. One explanation for this finding may be related to the finding that people who selectively attend to pain-related information are more sensitive for the presence of noxious stimuli [23] and have more difficulty in disengaging their attention from the presence of noxious stimuli [56]. A focus on pain cues or pain has indeed often found to be related to higher

pain severity [42,64] and more disability, i.e., worse task performance on concurrent tasks [9,55]. These findings are also in line with prominent theoretical frameworks that predict attentional bias to be an exacerbating or maintaining factor in chronic pain. These models assign a central role to attentional processes, i.e., attentional bias towards pain-related information, in a vicious circle in which chronic pain patients are caught [13,27,65]. However, as argued before, these are cross-sectional findings that do not allow for causal conclusions. It may also be the case that chronic pain patients develop an attentional bias towards pain-related information because they are constantly confronted with the presence of pain. The more they are disabled and the more severe their pain is, the more an attentional bias may be established. In this case attentional bias towards pain-related information may be just an epiphenomenon of chronic pain.

By using a prospective design we were able to investigate whether attentional bias towards pain-related information is predictive for daily disability, avoidance behaviour and distractibility while controlling for the current level of pain severity and other possible influencing variables, such as, age, gender and pain duration. Results showed that the attentional bias index was predictive for daily pain severity, but had no additional predictive value above the control variables. Only pain severity measured at baseline (and UCS pain rating for daily pain severity) had a unique predictive value for pain outcomes measured by means of the diary assessment, i.e., pain severity, avoidance, disability and distractibility.

It may also be that an attentional bias for pain-related information modulates the relationship between pain severity and other pain outcomes rather than it influences pain outcomes in itself. Indeed, recent theoretical advances

suggest that attentional bias may not directly amplify the experience of pain, but suggest that pain may evoke a more intense fear response in those who have an attentional bias towards pain-related information, which may then result in more avoidance behaviour, disability and distractibility of ongoing behaviour [13]. Our results partly support this view and show that the positive relationship between the reported pain severity and reported disability is stronger for people that selectively attend to pain-related information. A similar influence of attentional bias was found on the positive relationship between pain severity and distractibility. Indeed, it is reasonable to assume that for people who are highly attentive for pain cues or other pain-related information, the presence of moderate or severe pain may evoke a more intense fear response in comparison with people who are less attentive, which may then result in more disability and distraction of ongoing behaviour. When pain is absent or mild, this fear response will probably be absent in both groups. Following this reasoning, we also expected that attentional bias would moderate the relationship between pain severity and avoidance. This was not the case. One reason for this finding may be that people who show heightened attention towards pain and pain cues over time adapted their daily behaviour in such way that avoidance of some activities has become a habit and therefore not reported in the diary. They may then report a high level of disability but not be conscious anymore of the fact that they are avoiding activities. This idea is, however, speculative and further research is required to investigate this suggestion.

The current findings may also be interpreted in line with the attentional control theory formulated by Eysenck and colleagues (2007) in the anxiety domain [18]. Indeed, our attentional bias measure, i.e., modified spatial cueing task, may be interpreted as a reflection of cognitive interference by pain-related

information. In fact, the attentional bias index may be understood as a reflection of how well people can control the allocation of attention to goal-related behaviour and minimize the interference of pain-related information. It is reasonable to assume that a better control of attention to goal-related behaviour during the presence of pain-related information may then be reflected in less daily distractibility and disability by pain/ pain-related information in case pain is prominently present. In case that pain is absent or low, attentional control may be less important to execute current goal-related behaviour.

Our findings may also have clinical implications. Indeed, the current findings suggest that it is important for treatments in chronic pain patients to reduce attentional bias for pain-related information. In fact, our study indicates that a reduction in attentional bias may weaken the relationship between the presence of severe pain –which is inevitable for chronic pain patients- and disability and distraction due to the presence of pain. Several treatment options have been proposed. Recent findings suggest that attentional bias may be modified in such way that attention is directed away from fear-related information (e.g., [47]) and pain-related information (e.g., [33], but see [48]). Other treatment options that have been proposed are interventions that target the fear system and the threat value of pain as this has been argued to fuel attentional bias towards pain-related information [53,59]. This may be accomplished by challenging erroneous beliefs about pain [65], or by learning to accept that a meaningful life is also possible despite pain [32].

Some aspects of our study require further consideration. First, this is the first study that applies a modified spatial cueing task using pain cues as a means of assessing selective attention in patients with chronic pain. The use of pain cues rather than words describing pain features may be more appropriate

because cues that are predictive for pain may be more capable of activating bodily threat than words which are only semantic representations of pain [2,12,61]. Our findings, however, need replication. Second, research has shown that the reliability of attentional bias paradigms is poor [14]. This was also the case in our study. However, we had a low number of trials in our paradigm, and reliability may increase by increasing the number of trials. Definitely, more research is required to investigate the psychometric properties of attentional bias paradigms. Third, our sample was recruited via an invitation letter which was sent to all members living throughout Flanders. Only 10% actually responded. This could have influenced the representativeness of the study sample. The characteristics of the current study sample are however comparable with the samples of other studies (e.g., [37]; large proportion females, overrepresentation of highly educated people, back pain is most reported pain location).

Last, one might be surprised by the fact that we did not find an overall attentional bias towards pain-related information in this chronic pain sample. However, an explanation may be found in the specifications of the used paradigm and the investigated population. First we opted to use a pain stimulus of maximal 3 mA to increase the variability in the attentional bias index, rather than to find an attentional bias towards pain-related information per se. Second, we adapted the modified spatial cueing paradigm slightly in comparison with previous studies in healthy volunteers receiving experimental pain [57,58,59,62]. We opted to use a target categorization task rather than a target detection task. An advantage of this adaptation is that the bias index may only be attributed to an attentional mechanism, rather than a response preparation mechanism, as the location of the cue is not predictive of the required response [19]. However, it may also have reduced the attentional bias index as such. Third, a chronic pain population is

known to generally respond slower than pain-free participants. Indeed, general deficits in information processing have been frequently reported in patients with chronic pain [20,34]. This may have resulted in more noise in the reaction time data compared to studies in healthy volunteers. However, this was also the case for other research investigating attentional bias in chronic pain patients [2,30,43]. The use of an accuracy approach instead of looking at reaction time performance may be considered as a possible alternative for future research [40,60].

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