Does vigilance to pain make individuals experts in facial recognition of pain?

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BACKGROUND: It is well known that individual factors are important in the facial recognition of pain. However, it is unclear whether vigilance to pain as a pain-related attentional mechanism is among these relevant factors.
OBJECTIVES: Vigilance to pain may have two different effects on the recognition of facial pain expressions: pain-vigilant individuals may detect pain faces better but overinclude other facial displays, misinterpreting them as expressing pain; or they may be true experts in discriminating between pain and other facial expressions. The present study aimed to test these two hypotheses. Furthermore, pain vigilance was assumed to be a distinct predictor, the impact of which on recognition cannot be completely replaced by related concepts such as pain catastrophizing and fear of pain.
METHODS: Photographs of neutral, happy, angry and pain facial expressions were presented to 40 healthy participants, who were asked to classify them into the appropriate emotion categories and provide a confidence rating for each classification. Additionally, potential predictors of the discrimination performance for pain and anger faces – pain vigilance, pain-related catastrophizing, fear of pain – were assessed using self-report questionnaires.
RESULTS: Pain-vigilant participants classified pain faces more accurately and did not misclassify anger as pain faces more frequently. However, vigilance to pain was not related to the confidence of recognition ratings. Pain catastrophizing and fear of pain did not account for the recognition performance.
CONCLUSIONS: Moderate pain vigilance, as assessed in the present study, appears to be associated with appropriate detection of pain-related cues and not necessarily with the overinclusion of other negative cues.

Key Words: *Facial expression; Pain; Recognition; Vigilance to pain*

La vigilance envers la douleur fait-elle des individus des spécialistes de la reconnaissance faciale de la douleur?

HISTORIQUE : Il est bien connu que des facteurs individuels sont importants en matière de reconnaissance faciale de la douleur. Toutefois, on ne sait pas si la vigilance envers la douleur, en qualité de mécanisme attentionnel lié à la douleur, fait partie de ces facteurs pertinents.
OBJECTIFS : La vigilance envers la douleur peut avoir deux effets différents sur la reconnaissance des expressions faciales traduisant la douleur : les personnes vigilantes envers la douleur décèlent peut-être mieux les visages traduisant la douleur, mais incluent trop d'autres expressions faciales, les interprétant à tort comme des expressions de douleur, ou sont de véritables experts qui distinguent la douleur et d'autres expressions faciales. La présente étude visait à évaluer ces deux hypothèses. De plus, les chercheurs postulaient que la vigilance envers la douleur était un prédicteur distinct dont il est impossible de remplacer complètement les répercussions sur la reconnaissance de la douleur par des concepts connexes comme la catastrophisation et la peur de la douleur.
MÉTHODOLOGIE : Les chercheurs ont présenté des photos d'expressions faciales neutres, heureuses, colériques et traduisant la douleur à 40 participants en santé qui ont été invités à les classer dans les bonnes catégories d'émotion et à fournir une évaluation de confiance à l'égard de chaque classement. De plus, ils ont évalué les prédicteurs potentiels du rendement discriminatoire des expressions traduisant la douleur et la colère, soit la vigilance à la douleur, la catastrophisation liée à la douleur et la peur de la douleur, dans le cadre des questionnaires d'autoévaluation.
RÉSULTATS : Les participants qui étaient vigilants envers la douleur classaient les expressions faciales traduisant la douleur de manière plus précise et ne se trompaient pas davantage en classant la colère parmi les expressions faciales traduisant la douleur. Cependant, la vigilance envers la douleur n'était pas liée à la confiance envers le taux de reconnaissance. La catastrophisation et la peur de la douleur ne modifiaient pas le rendement de la reconnaissance.
CONCLUSIONS : Une vigilance modérée envers la douleur, telle qu'elle est évaluée dans la présente étude, semble associée à une détection convenable des indices liés à la douleur et pas nécessairement à une surinclusion d'autres indices négatifs.

The importance of the concept of pain vigilance has been demonstrated in many experimental and clinical studies during the past two decades, indicating pain vigilance to be associated with unfavourable pain outcomes (1). Pain vigilance is defined as a tendency to attentionally prioritize pain and pain-related stimuli among other stimuli in the external or internal environment (2); as such, pain vigilance has been demonstrated to be associated with emotional aspects of pain such as pain catastrophizing and fear of pain (3,4).

Pain vigilance is believed to bias attention not only toward true pain but also toward cues of pain, which may constitute a warning for imminent pain. The facial expression of pain by others is a powerful warning because it signals to the observer potentially threatening situations, including an increased likelihood of painful experiences. Such a warning cue captures most of the attention of the observers and is difficult to ignore (5-7). It is, therefore, plausible to assume that attention is allocated to facial pain expressions, and that the attention of pain-vigilant individuals is captured more easily than that of non-vigilant individuals. Indirect support for these two assumptions stems from two studies in which the attentional processing of pain cues was investigated using a dot-probe task, with painful facial expressions as stimuli. The results of Vervoort et al (4) suggest that faces expressing low levels of pain, and especially faces expressing moderate and high pain, are capable of engaging the attention of healthy onlookers. A study by Khatibi et al (3) indicated that chronic pain patients, as potentially hypervigilant individuals, shift their attention selectively to pain facial expressions and that this tendency is more pronounced in pain patients with greater fear of pain.

However, the brief processing of pain cues as investigated in the dot-probe task paradigm, which reflects attentional biases, may differ from the elaborated processing of such cues, which becomes possible in

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recognition tasks. Therefore, it is not clear whether the results obtained by the dot-probe task hold for facial recognition.

Whereas the facial recognition of the six basic emotions (joy, sadness, anger, disgust, fear, surprise) has been well researched (8,9), less research has been performed on the recognition of pain faces. The results of the few available studies (10-12) indicate that the recognition rates of pain (hit rates) among other facial expression of emotions are substantially higher than chance level but lower than recognition rates for almost all basic emotions. Rejection rates for pain (ie, correctly rejecting the response 'pain' when an emotion other than pain is displayed), however, are within the range of rejection rates for the other emotional displays. One study, using multidimensional scaling to examine which negative emotion prototype faces were perceived as being similar to pain, found pain to fall close to sadness and anger. Because this result cannot be entirely explained in terms of shared facial muscle movements, the authors assumed that these three expressions were rated as similar due to the common social messages conveyed in the faces (eg, the angry face associated with threat) (10).

It remains unclear whether similar individual factors that appeared to induce attentional biases in the dot-probe paradigm, such as hypervigilance and fear of pain, affect the facial recognition of pain. Because of the findings obtained in the dot-probe task, we are predominantly interested in the influence of pain-specific characteristics of the observer on facial pain recognition, although factors not specific to pain, such as empathy or social relatedness, are known to improve the recognition performance of affective faces (13). We assumed pain vigilance to be a promising candidate because the associated attentional engagement with pain-related cues may increase the competence of facial pain recognition. Because of the strong relationship between pain vigilance as an attentional factor and pain catastrophizing and pain-related fear as emotional factors (3,4), the latter two variables were also considered in the present study. In essence, pain vigilance was expected to add significant explanatory power to these two partially overlapping emotional concepts.

Based on these considerations, we hypothesized that recognition performance for faces expressing pain would be better in pain-vigilant individuals, which holds even if taking pain catastrophizing and fear of pain into account as additional predictors (Hypothesis A). However, it may be that their tendency to attentionally prioritize pain and pain-related stimuli results in an overinclusion of potentially negative cues, ie, to a reduced specificity in combination with an increased sensitivity for facial pain recognition (Hypothesis B1). Evidence for this assumption could be derived from anxiety research, in which patients show a vigilant attentional pattern, not only in the presence of their feared objects but also when marginally related stimuli are presented (14). Conversely, the continuous preoccupation with pain-related stimuli may also render pain-vigilant individuals well-informed regarding the exact features of pain signals, leading to both an increased sensitivity and specificity (Hypothesis B2). Therefore, these two partially conflicting hypotheses were tested in addition to our main hypothesis. Finally, to investigate whether pain-vigilant participants were aware of their presumed judgment competence, our participants were asked for confidence ratings for each of their judgments.

METHODS

Participants

Forty healthy Caucasian subjects between 19 and 46 years of age (mean [± SD] age 26.6±8.2 years; 20 men and 20 women) were recruited through announcements in newspapers and public buildings in Bamberg and among students of the University of Bamberg (Bamberg, Germany). The highest grade completed was elementary school in 2.5%, junior high school in 2.5%, high school in 85% and university in 10% of the subjects. Except for students, who participated to fulfill course requirements, all subjects were compensated for their participation. Each participant had normal or corrected-to-normal eyesight. Because gonadal hormones have been shown to influence pain sensitivity (15), the use of oral contraceptives was recorded and sessions were scheduled so that menstrual cycle phases were equally distributed. All participants provided informed consent and were free to withdraw from the experiment at any time. The study was approved by the Ethics Committee of the University of Bamberg.

Stimulus material

The difficulty of facial recognition depends both on the unambiguousness of the facial expression of interest and its categorical alternatives. Accordingly, the recognition task, which allowed for testing the likelihood of confusing facial expressions of alternative negative emotions with pain faces, required at least a second facial display that is likely to be regarded as similar to pain. Hence, the facial expression of anger was chosen as the categorical alternative to pain because it was found to be often blended with pain and perceived by observers to be similar to the facial expression of pain, due to similar levels of perceived threat and an overlap in facial muscle movements. To vary the difficulty of distinction between pain and nonpain faces, happy and neutral faces were used in addition to pain and angry faces. Such alternating presentations are believed to avoid response biases (10). Furthermore, the mixed presentation of faces expressing negative and positive emotions prevents the induction of one-sided mood states (16).

Photographs with painful, happy, angry and neutral faces were extracted from the Montreal Pain and Affective Face Clips (12). This pool of short coloured video clips is based on the facial displays of eight actors (50% females), who tried to present facial expressions of the six basic emotions (anger, joy, disgust, fear, sadness and surprise), a prototypical pain face and a neutral facial expression. Using the Facial Action Coding System (17), Simon et al (12) demonstrated that the actors displayed prototypical facial expressions and that these facial expressions could be differentiated by individuals.

For each of the four emotions (pain, anger, joy and neutral mood), five different snapshots were extracted from the video clips at the point of the apex expression. This resulted in a set of 160 photos (four emotions × five snapshots × eight actors). Although dynamic presentations are likely to evoke more vivid impressions of facial emotionality, snapshots were believed to be the better choice for the present study. Most experimental paradigms assessing attention and processing of emotion require the use of static pictures with definite stimulus on- and offset (eg, dot-probe task, evoked brain potentials). Because the intention was to compare findings reflecting explicit facial recognition with the data from such paradigms reflecting implicit processing of facial expressions, static pictures were used. It is known that hue, brightness and saturation of colours may influence the emotional state and arousal of the observer (18); therefore, black-and-white snapshots were used to match the pictures with regard to this potential influence.

Self-report questionnaires

The questionnaires used in the present study were the Pain Vigilance and Awareness Questionnaire (PVAQ), the Pain Catastrophizing Scale (PCS) and the Fear of Pain Questionnaire III (FPQ III).

The PVAQ (19) was developed as a comprehensive measure of attention to pain and has been validated for use in chronic pain and nonclinical samples (20,21). It consists of 16 items (eg, 'I am quick to notice changes in pain intensity'), with each item assessed on a six-point scale. The subscales of the PVAQ measure awareness, vigilance, preoccupation and observation of pain. The PVAQ demonstrated good internal consistency (Cronbach's α=0.86) and good test-retest reliability (RTT=0.80) (19). For further analyses, the combined sum score of the PVAQ was used, as advised in the literature (19). PVAQ total scores range from 0 to 80.

The PCS (22,23) was developed as a measure of catastrophizing related to pain. It contains 13 items (eg, 'I worry all the time about whether the pain will end') that can be divided into three subscales (rumination, magnification and helplessness). Each item is evaluated on a five-point scale. The PCS showed excellent internal consistency (Cronbach's α=0.95) for the general scale as well as good test-retest reliability (RTT=0.75) (22). The combined score of the PCS was used as has been recommended in previous studies (22,24). Total PCS scores range from 0 to 52. According to the user manual, a total PCS score of 30 represents a clinically relevant level of catastrophizing.

The FPQ III (25,26) was developed to measure the amount of fear that is related to pain. The FPQ III contains 30 items that can be divided into three subscales regarding the fear of three types of pain: severe ('breaking an arm'); minor ('paper cut on the finger'); and medical pain ('receiving an injection in the mouth'). Each item is evaluated on a five-point scale. The FPQ III demonstrated good internal consistency (Cronbach's α=0.92) (25). For further analyses, the combined sum score of the FPQ III was used, which ranges from 30 to 150.

The PVAQ and the FPQ III were subjected to a forward-backward procedure of translation, meaning that the German translation was the starting point for a translation back to English by an English native speaker (with German as his second language [27]). The translation into German was improved until the original English versions and the final English versions were sufficiently similar. The German versions of the PVAQ and FPQ III demonstrated good internal consistency (FPQ III: Cronbach's α=0.88; PVAQ: Cronbach's α=0.84), which corresponds well with coefficients reported for the English version. The German version of the PCS validated by Meyer et al (24) was used in the present study. All questionnaires were presented in paper and pencil form.

Procedure

At the beginning of the session, participants were informed about the general procedure and provided informed consent. To control for possible order effects, participants were randomly assigned to two groups, one beginning with the questionnaires and the other with the facial recognition task. The two sexes were balanced over the two order groups. No significant differences in the recognition performance and questionnaire scores were observed between the two order groups ($P>0.05$ for all comparisons when assessed by *t* test).

During the facial recognition task, participants were seated at a distance of 80 cm in front of a personal computer screen (27 cm × 36 cm Flatron F900P Monitor, LG, South Korea), resulting in a visual angle of 6.4° for the height and 7.8° for the width of the photos (9 cm × 11 cm). The size of the photos in combination with the presentation time for each photo (500 ms) did not allow for visual scanning.

The set of 160 photos was presented twice, each time in a different randomized order, so that each participant assessed a total of 320 photos. These two series allowed for the computation of split-half reliability. The presentation of each photo was followed immediately by the request of two types of ratings on the personal computer screen: first, a forced-choice rating of emotion recognition; second, a numerical rating of judgement confidence. The forced-choice rating included the five categories 'joy', 'anger', 'pain', 'neutral' and 'other emotion'. Judgement confidence ratings were assessed using a numerical ratings scale that consisted of 11 points ranging from 0 ('very unsure') to 100 ('very sure') with steps of 10. Both ratings were performed by mouse click. The second mouse click started the presentation of the next photo. The next photo was presented when 10 s had elapsed without a mouse click.

Indexes for recognition performance and judgement confidence

The hypotheses refer to the recognition performance of pain-vigilant subjects regarding the distinction of the facial expression of pain and anger. Therefore, analyses focused mainly on the indexes for pain and anger.

Recognition performance was operationalized as sensitivity (hit rate), specificity (correct rejection rate) and unbiased hit rate (28). Because an optimal sensitivity may also be achieved by a nondiscriminative repetition of the same answer (eg, by calling all faces 'pain faces' or by calling all faces 'anger faces'), the computation of the specificity index was required for correction. Specificity describes the percentage of correctly not calling a face 'pain face' when anger was presented or vice versa. To control for variations in item difficulty, the error-corrected item difficulty index was calculated for all items using the following formula (29):

$$100 \times (\text{n correct response} - [\text{n false response}/(\text{response alternatives} - 1)])/\text{n}$$

Thereafter, values for sensitivity and specificity were corrected by multiplication with the item difficulty index. Due to this correction, the optimal scores for sensitivity and specificity were lower than 100% (maximal scores for sensitivity after correction: pain 93.88%; anger 81.69%; maximal scores for specificity: pain 59.96%; anger 61.25%).

The unbiased hit rate was calculated as an additional indicator of the recognition performance (28). The raw hit rate may cause problems because it fails to take into account a possible bias in the use of the available response categories. The unbiased hit rate is based on the raw hit rate corrected by the false alarm rate and ranges from 0% to 100%. The unbiased hit rate was calculated using the following formula:

$$(\text{True positives}/[\text{true positives} + \text{false negatives}]) \times (\text{True positives}/[\text{true positives} + \text{false positives}])$$

The unbiased hit rate is a widely used parameter for recognition performance (28) and, thus, may not only add important information to the analyses but may also simplify the comparability of the results with the results of recent studies. However, this parameter is not statistically independent from the sensitivity and specificity index.

Judgement confidence is the simple mean of confidence scores computed over all anger or pain faces, respectively, for each individual.

Analyses

Hypotheses were tested using hierarchical multiple regression analyses. Criterion variables were: corrected sensitivity for pain and anger; corrected specificity for pain and anger; unbiased hit rate for pain and anger; and judgement confidence for pain and anger. With regard to the role of the predictor variables, it was assumed that pain hypervigilance (PVAQ) as a pain-related attentional mechanism plays a major role in explaining the variance of recognition performance for pain faces and, thus, adds significant explanatory power to the predictor set of negative emotions related to pain (eg, pain catastrophizing and fear of pain). To test these assumptions, the sum scores of the PCS and FPQ III were entered in a first step, followed by a second step in which the sum score of the PVAQ was entered. To avoid α inflation, the analyses were Bonferroni corrected for multiple testing, resulting in a significance level of α=0.006 for this part of the analyses.

Furthermore, dependent *t* tests were applied for testing category differences (pain, anger) in all recognition performance parameters, and Pearson correlations were applied for the description of the relationship between questionnaires and recognition parameters; α was set at 0.05 for these changes.

RESULTS

Descriptive data, correlations and *t* tests

The descriptive statistics of the questionnaire data and the data from the recognition performance task are summarized in Table 1. The questionnaire scores of the PVAQ, the PCS and the FPQ III are typical for healthy subjects (21,23,25,26).

Before conducting additional statistical tests on the recognition parameters, their reliability (split-half) was assessed. Pearson correlations between the two series of 160 photos ranged from r=0.67 to r=0.91 according to the parameter considered, suggesting highly sufficient reliability of the data.

The sensitivity as well as the specificity for recognizing pain and anger were significantly different (sensitivity: T=2.30; P=0.027; Cohen's d=0.63; specificity: T=2.58; P=0.014; Cohen's d=0.63). The sensitivity and the specificity for recognizing pain faces were

TABLE 1
Descriptive statistics from questionnaire scores and sensitivity, specificity, unbiased hit rate and confidence judgement parameters for the recognition of the facial display of pain and anger

	Mean ± SD	Range
PVAQ	33.08±11.17	9–60
PCS	16.70±7.60	3–30
FPQ III	73.90±14.28	46–102
Sensitivity for pain*	63.81±21.05	19.95–91.53
Sensitivity for anger*	56.37±16.81	6.13–77.61
Specificity for pain*	58.12±3.12	47.22–59.96
Specificity for anger*	55.64±5.00	43.64–61.25
Unbiased hit rate for pain faces	63.05±21.77	20.32–95.00
Unbiased hit rate for anger faces	59.93±19.08	1.45–91.27
Judgement confidence for pain	76.55±12.49	46.88–96.17
Judgement confidence for anger	72.58±11.17	49.63–92.79

**Values reported were corrected by the error-corrected item difficulty index. FPQ III Fear of Pain Questionnaire; PCS Pain Catastrophizing Scale; PVAQ Pain Vigilance and Awareness Questionnaire.*

significantly higher compared with recognizing anger faces. The unbiased hit rate did not differ between recognizing pain or anger faces (T=0.96; P=0.341; Cohen's d=0.00).With regard to the judgement confidence, subjects were more confident in judging pain correctly than anger (T=3.68; P=0.001; Cohen's d=0.95).

Regression analyses

The results of all regression analyses are presented in Table 2.

Recognition performance for pain faces: With regard to the recognition sensitivity for pain faces, step one in the regression analysis – when pain catastrophizing (PCS) and fear of pain (FPQ III) were entered – did not show any significant effect. Adding the PVAQ in the second step led to a significant improvement of explained variance of 18% in the regression model (ΔR^2=0.18; P<0.005).

The same procedure was repeated for the prediction of the recognition specificity for pain faces, but failed to produce a significant effect for all predictors.

The regression analysis of the unbiased hit rate for pain faces revealed that the amount of variance explained when entering the predictors (PCS, FPQ III) in step 1 was not significant; however, it was significant for the second step (ΔR^2=0.23; P<0.001), in which the PVAQ was entered as predictor.

Recognition performance for anger faces: The regression analysis testing the prediction of the recognition sensitivity for anger faces showed no significant effects.

In the regression analysis, testing the prediction of the recognition specificity for anger faces revealed that the combination of PCS and FPQ III entered in the first step explained a sizeable 17% of the variance (R^2=0.17; P=0.032) of the specificity for anger, with a larger contribution of the FPQ III (ß=−0.49; P=0.007). Due to the necessary Bonferroni α-adjustment (α=0.006), however, these results did not become significant. The PVAQ also did not appear to be a significant predictor.

No significant effects were found in the regression analysis for the prediction of the unbiased hit rate for anger faces.

Judgement confidence for pain and anger faces: Regression analyses comprising judgement confidence for the recognition of pain and anger faces failed to produce any significant effects regarding all predictor variables.

For a better understanding of the covariance relations of all measures entered into regression analyses, Table 3 presents Pearson correlation coefficients for their inter-relationships. Most importantly, the PVAQ showed substantial correlations with the recognition performance, ie, with the sensitivity and the unbiased hit rate for pain faces (sensitivity: r=0.52; P=0.001; unbiased hit rate: r=0.57; P<0.001,

TABLE 2
Stepwise regression analyses with pain vigilance, pain catastrophizing and fear of pain as predictors and the recognition parameters sensitivity, specificity, unbiased hit rate and judgement confidence for pain and anger as criterion (n=40)

Step	ΔR²	P	Predictor	t	ß	P
Criterion: Sensitivity for pain						
Step 1	0.12	0.088	PCS	1.09	0.19	0.283
			FPQ III	−0.84	−0.13	0.409
Step 2	0.18	0.005	PVAQ	3.01	0.47	0.005
Criterion: Specificity for pain						
Step 1	0.00	0.938	PCS	0.03	0.01	0.075
			FPQ III	−0.38	−0.07	0.710
Step 2	0.00	0.765	PVAQ	0.30	0.06	0.765
Criterion: Unbiased hit rate for pain						
Step 1	0.13	0.071	PCS	1.13	0.19	0.266
			FPQ III	−1.28	−0.20	0.208
Step 2	0.23	0.001	PVAQ	3.61	0.54	0.001
Criterion: Sensitivity for anger						
Step 1	0.12	0.098	PCS	1.64	0.31	0.110
			FPQ III	−0.60	−0.11	0.551
Step 2	0.02	0.386	PVAQ	0.88	0.15	0.386
Criterion: Specificity for anger						
Step 1	0.17	0.032	PCS	0.46	0.08	0.652
			FPQ III	−2.86	−0.49	0.007
Step 2	0.04	0.188	PVAQ	1.34	0.23	0.188
Criterion: Unbiased hit rate for anger						
Step 1	0.11	0.116	PCS	1.51	0.29	0.139
			FPQ III	−1.18	−0.21	0.246
Step 2	0.04	0.225	PVAQ	1.24	0.23	0.225
Criterion: Judgement confidence for pain						
Step 1	0.03	0.562	PCS	0.44	0.09	0.660
			FPQ III	−1.07	−0.20	0.293
Step 2	0.00	0.970	PVAQ	0.01	0.01	0.970
Criterion: Judgement confidence for anger						
Step 1	0.01	0.872	PCS	0.81	0.16	0.423
			FPQ III	−0.37	−0.07	0.712
Step 2	0.03	0.313	PVAQ	−1.02	−0.19	0.313

FPQ III Fear of Pain Questionnaire; PCS Pain Catastrophizing Scale; PVAQ Pain Vigilance and Awareness Questionnaire

respectively). A similar pattern was observed for the PCS, but with only medium-size correlation coefficients (r=0.34 for both; P<0.05). Furthermore, participants with a high fear of pain showed poor performance in rejecting pain faces as nonanger faces (specificity for anger: r=−0.38; P=0.015), meaning that pain faces were more frequently identified as anger faces.

In summary, corresponding well with the hypotheses, pain-vigilant subjects succeeded in detecting pain in faces supposed to be expressing pain (high recognition sensitivity and high unbiased hit rate for pain faces). However, higher levels of pain vigilance did not appear to be associated with correctly rejecting anger faces as nonpain faces (recognition specificity for pain) or increased confidence in this expertise (confidence judgement).

DISCUSSION

The aim of the present study was to examine how pain vigilance as an attentional style affects the recognition of facial pain expressions. We assumed that pain-vigilant individuals would be better in recognizing pain faces, despite their level of fear of pain or pain catastrophizing (Hypothesis A). However, the hypothesized higher recognition rates for pain faces in pain-vigilant individuals may arise from two alternative patterns of recognition performance, which were tested in our

TABLE 3
Pearson correlations between questionnaires and the recognition parameters sensitivity, specificity, unbiased hit rate and judgement confidence

	2	3	4	5	6	7	8	9	10	11
Questionnaires										
1. PVAQ	0.46†	0.28	0.52‡	0.27	0.04	0.13	0.57‡	0.29	–0.01	–0.13
2. PCS		0.48†	0.34*	0.33*	–0.00	–0.05	0.34*	0.29	–0.00	0.04
3. FPQ III			0.09	0.09	–0.05	–0.38*	0.05	–0.01	–0.16	–0.04
Sensitivity										
4. For pain				0.43†	–0.26	0.46†	0.92‡	0.51†	0.32*	0.18
5. For anger					–0.02	0.08	0.40†	0.94‡	0.11	0.16
Specificity										
6. For pain						–0.08	0.11	–0.01	–0.11	–0.00
7. For anger							0.45†	0.34*	0.34*	0.17
Unbiased hit rate										
8. For pain								0.51†	0.27	0.14
9. For anger									0.18	0.19
Judgement confidence										
10. For pain										0.84‡
11. For anger										

*FPQ III Fear of Pain Questionnaire; PCS Pain Catastrophizing Scale; PVAQ Pain Vigilance and Awareness Questionnaire. *$P<0.05$; $^{\dagger}P<0.01$; $^{\ddagger}P<0.001$*

experiment: Pain-vigilant subjects recognize pain faces better because of their enhanced selective attention to threatening stimuli such as pain cues, but they do that at the expense of confusing other negative faces (ie, anger) with pain faces more frequently (high sensitivity and low specificity for recognizing pain in the facial display of others [Hypothesis B1]); Pain-vigilant individuals are continuously occupied with processing pain-related cues, such as the facial display of pain, and become true experts in discriminating the facial display of pain from the facial display of other negative emotions (high sensitivity and high specificity for recognizing pain in the facial display of others [Hypothesis B2]).

The results of the present study confirm our first hypothesis: the higher the pain vigilance, the better the recognition of pain faces (high recognition sensitivity for pain faces [Hypothesis A]). Furthermore, highly pain-vigilant participants did not perceive anger faces to be pain faces more frequently than participants with low pain vigilance, demonstrated by similar recognition specificity for pain faces. This implies that highly pain-vigilant participants did not gain high sensitivity scores by simply identifying each emotional facial display as a pain face, which partially corroborates Hypothesis B2. This conclusion was strongly supported by results regarding the unbiased hit rate, which controls the recognition rate for pain faces for mere response bias effects. Here, pain vigilance proved to predict – in comparison, best – the recognition performance for pain faces while minimizing the effects of response biases.

In our experiment, we assessed only recognition accuracy and did not record the reaction times of participants in the recognition task. Therefore, we cannot eliminate the possibility that participants high and low in pain vigilance differed in their recognition speed. Because information most relevant for survival must be processed both rapidly and efficiently (30), pain-vigilant individuals may appear to be less superior when the trade-off between accuracy and speed is also considered compared with a selective consideration of accuracy.

Interestingly, the vigilance to pain did not predict the rating of recognition confidence for pain faces, although it predicted the recognition performance; ie, participants who were highly vigilant to pain performed very well in the recognition task without being aware of this efficiency.

We assumed pain vigilance to be a promising predictor of recognition task performance for pain faces: its focus is on the allocation of attention to and the elaborated procession of such stimuli, both of which are essential preparatory steps for developing recognition competency. Thus, pain vigilance was expected to add significant explanatory power to partially overlapping concepts, such as pain catastrophizing and fear of pain, that are less cognitively and more emotionally defined. This idea was confirmed by the present findings. However, the fear-avoidance model of chronic pain can be used for similar predictions. This model states that pain catastrophizing predisposes toward pain-related fear, and pain-related fear leads to increased vigilance for pain cues (31). Therefore, pain vigilance could be the variable with most explanatory power because of its proximal position to pain in that sequence of related processes (32).

Thus far, the hypothesized direction of relationships has been that high levels of pain vigilance lead to better recognition performance for pain faces. However, because our data are correlational, it may also be the case that enhanced recognition sensitivity for pain faces develops a habitual tendency to attend to pain signals, described as pain vigilance.

Our findings are restricted to explicit pain vigilance, ie, to the self-experience and the self-report of being vigilant to pain-related information. The question arises whether parameters based on behavioural and physiological measures of attentional prioritizing of pain-related stimuli also suggest that pain-vigilant individuals are especially competent in recognizing the facial display of pain. Because we know that these more implicit measures are not related to those that are more explicit (33,34), future research is necessary to clarify whether implicit pain vigilance also improves facial pain recognition.

The correlations among our predictors warrant a few comments. Pain catastrophizing, but not fear of pain, appeared to be significantly correlated with pain vigilance. In a critical review, Quartana et al (35) proposed that pain catastrophizing is associated with a heightened attentional bias to pain-relevant stimuli. The authors emphasized that it is unclear whether this relation is moderated by negative emotionality such as fear of pain. The very weak correlation between fear of pain and pain vigilance in the present study makes a direct effect unlikely, yet still allows for moderator effects. However, our data were not powered to detect moderator effects, and complete moderator analyses should be based on a larger sample than ours, which makes firm conclusions very difficult.

Several limitations to the present study should be mentioned. The study sample consisted of pain-free individuals displaying low to medium levels of pain vigilance. Generalization to pain patients and individuals with established hypervigilance requires further research. Another limitation was the smaller interindividual variance of the specificity index compared with the other recognition parameters. The lack of significant correlations when including the specificity index may be partly due to this statistical shortcoming. A further point of discussion may be the sequence of entering predictors in the regression analyses, which was derived from the fear-avoidance model (31).

Recent findings by Wideman et al (36) suggested that a different sequence of those emotional and attentional processes may also be conceivable, which in turn may change the theoretically optimal order of entering predictors. Finally, certain features of the stimulus material are worth discussion. Recognition of facial display of emotions is improved when the facial dynamics are available by showing video clips (12), which may also provide better ecological validity. Nevertheless, we refrained from doing so because of the benefits of comparing our data with data from the many other paradigms using static pictures. Moreover, realistically, facial displays are not categorically separated, and various emotions blend continuously with pain, rendering recognition more difficult. However, the latter limitations regarding the stimulus material have been deliberately approved to increase methodological control. Furthermore, we believe that one of the best available picture sets in which pain is included was used in the present study.

In summary, highly pain-vigilant individuals are superior in recognizing pain faces when presented. However, they do not achieve this at the expense of classifying all faces expressing negative emotional states as pain faces. Furthermore, vigilant participants were not aware of their recognition capacity.

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