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Experimental Study

# Can People with Chronic Neck Pain Recognize Their Own Digital Pain Drawing?

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**Background:** Although the reliability of pain drawings (PDs) has been confirmed in people with chronic pain, there is a lack of evidence about the validity of the PD, that is, does the PD accurately represent the pain experience of the patient?

**Objectives:** We investigate whether people with chronic neck pain (CNP) can recognize their own PD to support the validity of the PD in reporting the experience of pain. Moreover, we examined the association between their ability to recognize their own PD with their levels of pain intensity and disability and extent of psychosocial and somatic features.

**Study Design:** Experimental.

**Setting:** University Laboratory.

**Methods:** Individuals with CNP completed their PD on a digital body chart, which was then automatically modified with specific dimensions using a novel software, providing an objective range of distortion and eliminating errors, which could potentially occur in manually controlled visual-subjective based methods. Following a 10-minute break listening to music, a series of 20 PDs were presented to each patient in a random order, with only 2 being their original PD. For each PD, the patients rated its likeliness to their own original PD on a scale from 0 to 100, with 100 representing "this is my pain."

**Results:** Overall, the patients rated their original PD with a median score of 92% similarity, followed by 91.8% and 89.5% similarity when presented with a PD scaled down to 75% and scaled up by 150% of the original size, respectively; these scores were not significantly different to the ratings given for their original PD. The PD with horizontal translation by 40 pixels (8%) and vertical translation by 70 pixels (12.8%) were rated as the most dissimilar to their original PD; these scores were significantly different to their original PD scores. The Spearman correlation coefficient revealed a significant negative association between their ability to recognize their original PD and their Modified Somatic Perceptions Questionnaire scores.

**Limitations:** The patients in the study presented with relatively mild CNP, and the results may not be generalized to those with more severe symptoms.

**Conclusions:** People with CNP are generally able to identify their own PD but that their ability to recognize their original PD is negatively correlated with the extent of somatic awareness.

**Key words:** Chronic pain, perception, pain drawings, somatic awareness

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The first question asked of anyone complaining of pain typically relates to its location (i.e., where does it hurt?). Mapping the spatial properties of pain is considered an essential component of musculoskeletal assessment and related methods, and tools have been developed to facilitate the measurement and recording of its location and extent.

Accordingly, pain charts and pain drawings (PDs) have become ubiquitous in the clinical management of pain and have become a trusted tool for clinicians undertaking related assessments. Pain charts are typically visual templates made up of simple line drawings of a human body or body segment viewed from different perspectives. The approach is then to sketch the area of pain directly onto the template; this may be completed by a clinician who maps the relevant area from the patient's description, or the patient may be invited to sketch the area directly themselves.

The process of mapping one's pain spatially onto a visual template appears to require an intact and accurate representation of the body. Important findings from studies in recent years have highlighted deficits in body representation that can exist in individuals with chronic pain. For example, patients may perceive the painful area of their body to be altered in size (1), may demonstrate deficits in the positional sense of the area (2), and in some cases may have difficulty recognizing the laterality of a visual representation of the body part (3). However, it should be noted that such findings have mainly been confined to relatively severe forms of chronic pain affecting the upper limb, although some related findings in patients with chronic spinal pain have also been demonstrated (4,5).

These studies typically evoke explanations that relate to a specific type of body representation know as body schema. Body schema refers to the ability to recognize the position of one's body and body parts/segments in time and space. However, the emphasis placed on body schema in interpreting body representation data in recent pain research has perhaps been overstated (6), and in some cases, studies have demonstrated that certain underlying assumptions are incorrect (7). A second form of body representation that humans possess is known as body structural description (8). Rather than relying on the online awareness of one's own body in time and space (such as body schema), body structural description refers to the ability to recognize body parts/segments in relation to one another, and within a standard body using visual information.

Given these different representations of the body that exist, it is worth considering the process required for an individual to complete a PD. The individual must be able to spatially locate the position(s) and extent(s) of their own pain, and then transfer this onto a topological map of the body using visual input. It seems likely that this requirement primarily engages body structural description as a form of body representation to complete the PD task.

Although the reliability of digital PDs has been confirmed in people with chronic pain (9) and in acute painful conditions (10), there is a lack of evidence about the validity of the PD, that is, does the PD accurately represent the pain experience of the patient? A reference standard to establish the pain location and its extent is not available, but we may speculate that if the reported drawings correspond to a valid representation of the patient's pain they should be able to recognize their PD among other drawings that do not accurately represent their pain experience. Such information is relevant to support the validation of PDs. Given that a PD should represent a patient's familiar painful area(s), it is expected that if presented with the same or different drawings then the patient should be able to recognize their own pain and any distortion in terms of location and extent.

In this study, we uniquely evaluate whether women with chronic neck pain (CNP) can recognize their own digital PD. This was achieved by presenting the patients with a series of PDs, which included their PD among a number of digitally modified PDs. The modifications of the PD were generated with specific dimensions using a novel software, providing us with an objective range of distortions. This eliminated potential errors that could occur in manually controlled visual-subjective based methods. Their capacity to recognize their own PD was evaluated in relation to their score on several pain related questionnaires and questionnaires related to their psychological health. We focused on people with CNP because there is substantial evidence that individuals with CNP present with proprioceptive deficits (11-14), impaired postural control (15,16), and maladapted pain cognitions (16,17), which prompt the investigation of the perception of the painful area in people with CNP, yet our cohort are unlikely to present with significant changes in the somatotopic representation of the painful region in the cortex, unlike, for example, patients with phantom limb pain (4). The knowledge gained from this study will help to validate the use of PDs in reporting the experience of pain and may provide new

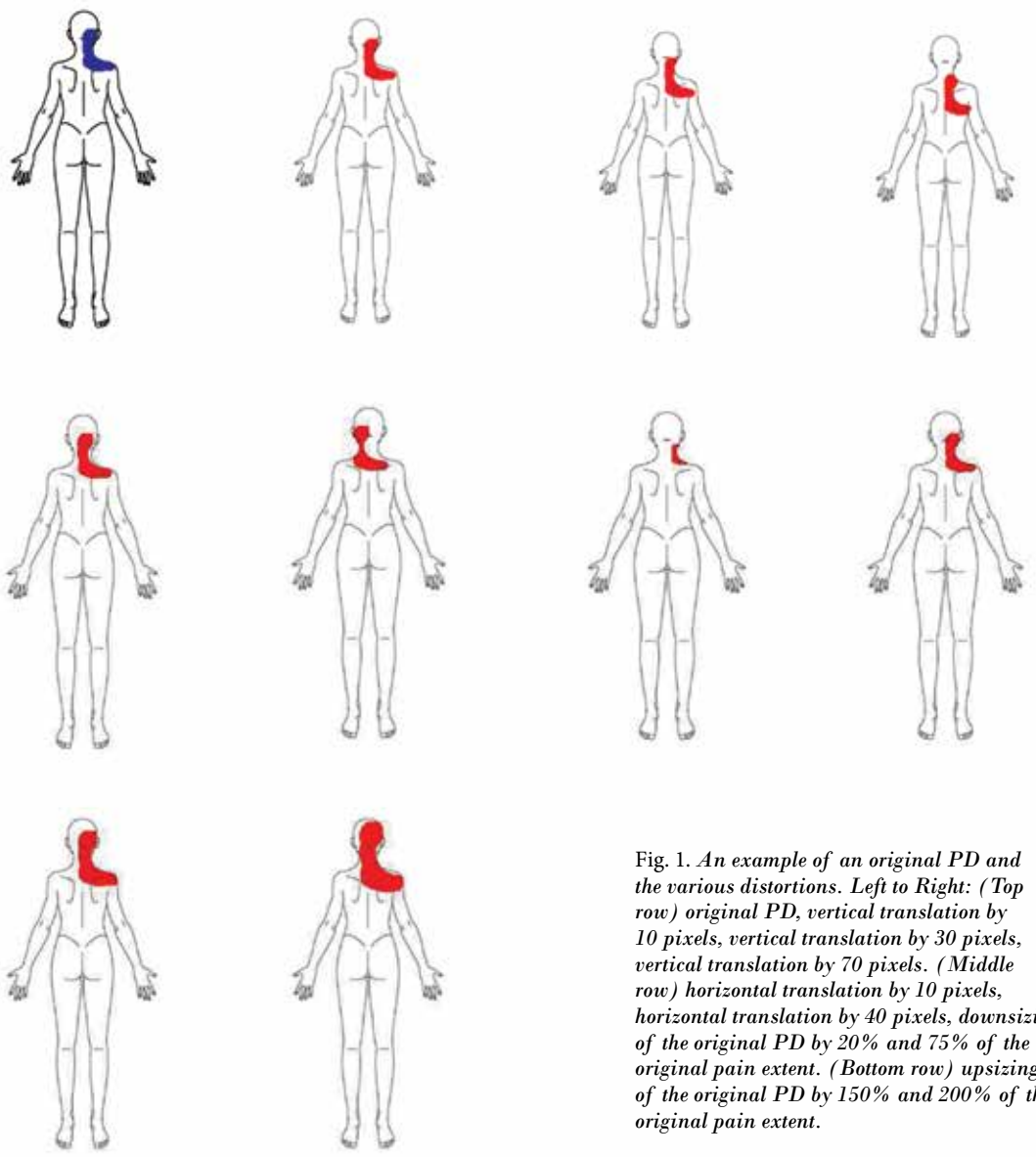

Fig. 1. *An example of an original PD and the various distortions. Left to Right: (Top row) original PD, vertical translation by 10 pixels, vertical translation by 30 pixels, vertical translation by 70 pixels. (Middle row) horizontal translation by 10 pixels, horizontal translation by 40 pixels, downsizing of the original PD by 20% and 75% of the original pain extent. (Bottom row) upsizing of the original PD by 150% and 200% of the original pain extent.*

insights into pain and body perception in people with CNP.

## Methods

The experimental sessions of this repeated measures study were conducted in a laboratory at the Centre of Precision Rehabilitation for Spinal Pain, University of Birmingham, UK between March and June 2018. Ethical approval was granted by the ethics committee of the School of Sport, Exercise and Rehabilitation Sciences, University of Birmingham, UK. This experimental study was conducted according to the Declaration of Helsinki. STROBE guidelines were used to report the findings. All patients were provided with an information leaflet and provided written informed consent prior to the session.

### Patients

The sample size included 20 women with CNP with a median age of 26 years (interquartile range, 2-32 years), recruited from the staff and student population

of the University of Birmingham. The sample size was based on the availability of the number of consenting patients between the period of March and June 2018. Only women were included, considering the higher prevalence of neck pain in women compared with men (18). Inclusion criteria consisted of the presence of CNP for at least 3 months and aged between 18 and 60 years. Patients were excluded if they reported fibromyalgia or a widespread pain disorder, previous cervical spine surgery, history of neurologic disorders, were receiving any active management, neck injury that resulted in a spinal fracture, rheumatologic condition, or had an ongoing compensation claim as part of an injury.

## Questionnaires

The patients first completed a general questionnaire, which detailed their age and duration of CNP. Their average pain intensity over the last week was measured using a Numeric Rating Scale (NRS-11) from 0 to 10, in which 0 indicates "no pain" and 10 indicates "the worst possible pain." The test–retest reliability (intraclass correlation coefficient, 0.76; 95% confidence interval, 0.51–0.87) of the NRS-11 for pain intensity among people with CNP has been established (19). Neck pain related disability was assessed using the Neck Disability Index (20), which consists of 10 items, with a maximum score of 50 with each item graded from 0 (no activity limitations) to 5 (major activity limitations). The score is then expressed as a percentage (0%-100%), with higher scores representing a higher level of disability. It is a reliable and valid instrument for measuring disability among people with CNP with an intraclass correlation coefficient up to 0.98 (21). The Depression Anxiety and Stress Scale (DASS-42) was used, which is divided into 3 subscales consisting of 42 symptoms. Each subscale—depression scale, anxiety scale, and stress scale— has 14 items. Patients were instructed to rate each symptom on a 4-point Likert scale ranging from 0 (did not apply to me at all) to 3 (applied to me very much, or most of the time) (22). The clinimetric properties of the questionnaire have been examined in patients with chronic pain (23). The Pain Catastrophizing Scale (PCS) was used to evaluate catastrophizing thoughts or feelings that accompany the experience of pain and consists of 13 items (24). The patients were asked to consider their past painful experiences and to specify the degree to which each of the 13 thoughts or feelings mentioned in the scale were experienced when in pain, graded on a 5-point scale (0 = not at all to 4 = all the time). Total score ranges between 0 and 52, with higher scores indicating a greater pain catastrophizing state. The scale has been tested in patients with CNP (25). The frequency and breadth of diffuse somatic complaints was measured with the Modified Somatic Perceptions Questionnaire (MSPQ), which is a 22-item instrument developed specifically for use for patients with chronic pain (26). Patients were asked to rate the degree to which they had experienced the mentioned symptoms during the past week on a 4-point Likert scale ranging from 0 (not at all) to 3 (extremely could not have been worse), with a maximum of 39 for the 13 symptoms (27).

## Procedure

The experimental session included the patient completing questionnaires, performing their PD followed by the recognition phase of their PD. The patients were given a 10-minute break listening to music between their original PD and the PD recognition phase. They were not told at the beginning of the session that they would subsequently be asked to recognize their own PD.

All patients were requested to complete their PD on a dorsal view of the upper body using the standard instruction, "Draw on this body chart where you felt pain over the last week and try to be as precise as possible." They were also advised to shade their pain independently from the type and the severity of pain, as described previously (9). PDs were completed on a tablet (iPad2; Apple Computer, Cupertino, CA), using a stylus pen (CS100B; Wacom, Vancouver, WA) and a custom designed app. The characteristics of the stylus pen including the type, size, and color were standardized (one dot of the stylus pen corresponded to 104 pixels). Any drawing generated outside of the body chart was not registered.

Following the 10-minute rest, a series of 20 PDs were then presented in a random order on a computer screen with 2 of these being their original PD. For each PD, the patient was asked to rate the likeness of the PD to their own pain on a scale from 0% to 100%, with 0 defined as "not at all like my pain" and 100 defined as "this is my pain." There was no time limit imposed on the patient when deciding the score for each PD.

## Processing of the PD

The original PD was processed and modified using a customized MATLAB (MathWorks, Natick, MA) script as follows, and an example is illustrated in Fig. 1:

- Vertical translation of the original PD of 10, 20, and 70 pixels. The direction of the translation, caudal or cranial, was chosen by the operator according to the PD location on the body chart, to avoid an error with the PD displacing out of the dorsal body chart boundaries.
- Horizontal translation of the original PD of 10 and 40 pixels. The direction of the translation, left or right, was chosen by the operator according to the PD location on the body chart, to avoid an error with the PD displacing out of the dorsal body chart boundaries.
- Downsize of the original PD of 20% and 75% of the original pain extent (expressed in pixels).
- Upsize of the original PD of 150% and 200% of the original pain extent (expressed in pixels).

### Statistical Analysis

The distribution of the data were evaluated with the Shapiro–Wilk test ($P < 0.05$) and nonnormally distributed data were observed, therefore nonparametric tests were used for data analyses as detailed later. Descriptive statistics were used to detail patient's age, CNP duration, pain intensity, and other health-related characteristics including disability, psychological, and somatic factors.

The Friedman 2-way analysis of variance by ranks was used to verify whether the similarity scores reported by the patients for their original PDs were significantly different from those obtained for the PDs modified with vertical and horizontal translation or upsize and downsize scaling. Moreover, the Friedman test was used to test the similarly scores reported for the 2 original PDs.

The association between patient characteristics and the similarity scores for original PD were investigated with the Spearman correlation coefficient. Statistical analyses were performed using IBM SPSS Statistics 24.0.0 (IBM Corporation, Segrate, Milano, Italy).

## Results

Patient characteristics are presented in Table 1. Data were missing from one subject for one of the PDs, which happened to be an original PD, however, all other data were available for this patient, and therefore this patient's data (apart from the one score) were retained in the analysis.

Scores of the degree of similarity of the PDs to the original PD are displayed in Fig. 2. The patients rated their original drawing with 92% similarity and there was not a significant difference ($P > 0.05$) in their rating of the 2 original PDs as shown in Fig. 3.

Table 1. *Patient characteristics*.

| | Median (interquartile range) |
|---|---|
| Age (years) | 26 (21–32) |
| Pain duration (years) | 4.25 (1.25–10) |
| Pain<br>NRS-11 (0–10) | 3 (3–5) |
| Disability<br>NDI (0%–100%) | 21 (15.2–35.5) |
| Psychosocial features<br>PCS (0–52)<br>PCS–R (0–16)<br>PCS–M (0–12)<br>PCS–H (0–24)<br>DASS (0–42)<br>DASS–D (0–42)<br>DASS–A (0–42)<br>DASS–S (0–42) | <br><br>6.5 (0.25–9.5)<br>3.5 (1.25–6)<br>5.5 (3.25–12)<br><br>4 (0–8.75)<br>7.5 (1–12.25)<br>11 (7–18.75) |
| Somatic features<br>MSPQ (0–39) | <br>9.5 (4–14) |

Values are expressed as median (interquartile range: 25th to 75th percentile).
Abbreviation: NDI, Neck Disability Index.

The patients were able to detect the modification of their PD when it was horizontally translated by 40 pixels and vertically translated by 70 pixels with similarity scores of 8.0% and 12.8%, respectively (Fig. 4). The patients detected most dissimilarity in the PD when it was horizontally translated by 40 pixels, vertically translated by 30 pixels, and vertically translated by 70 pixels, all presenting with a significant difference ($P < 0.05$) in similarity scores to the original PD. The horizontal shift by 10 pixels was also significantly different ($P < 0.05$) from the original PD score. The PDs modified by vertical translation of 10 pixels was rated overall with a 79% similarity score, which was not significantly different from the original PD score.

However, the patients could not identify the dissimilarity between their own original PD and the modification of their PD when downscaled to 75% and upscaled by 150%, with similarity scores of 91.8% and 89.5%, respectively (both $P > 0.05$; Fig. 5). In contrast, the patients rated dissimilarity for the PDs downscaled to 20% and upscaled by 200%, both significantly different ($P < 0.05$) to the scores for the original PD.

The Spearman correlation coefficients between the similarity scores of original PDs (average across the 2 trials) and patient characteristics are presented in Table 2. A significant negative correlation was observed between an ability to recognize the original PD and the MSPQ

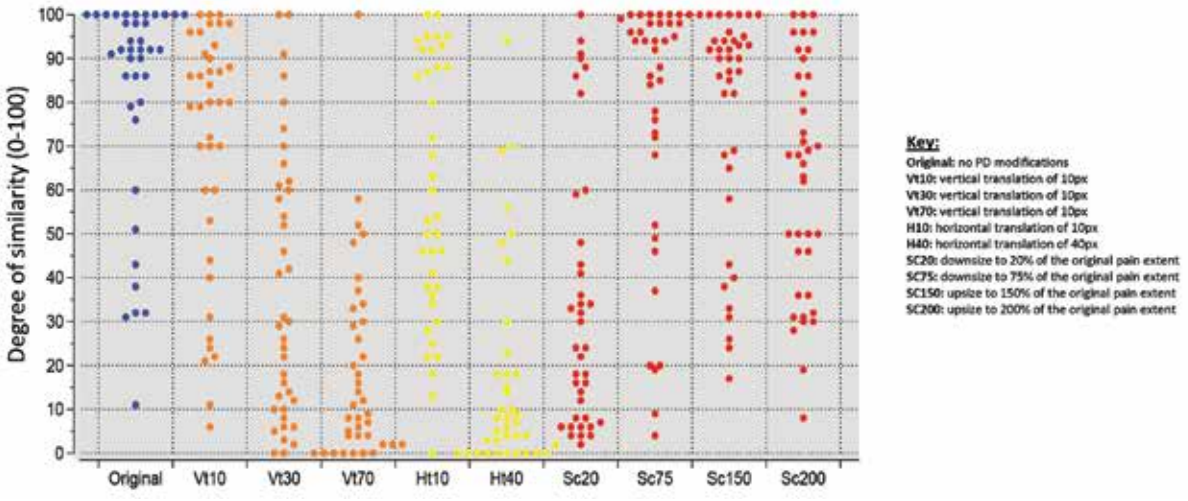


Fig. 2. *Individual scores of the degree of similarity reported by the patients (n = 20) on a scale ranging 0 to 100 (y-axis) for the original and modified PDs (x-axis).*

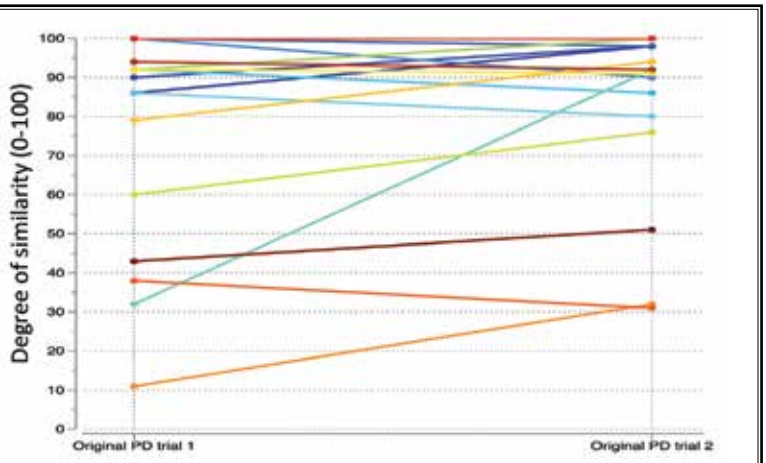


Fig. 3. *Patients (n = 19, as one subject failed to score one of the original PDs) exhibited consistency in recognizing their original PDs during the 2 trials (original PD trial 1 and original PD trial 2) with no significant difference between the similarity scores.*

scores. The NRS-11 score for pain intensity, anxiety subscale of DASS-42, and magnification component of the PCS exhibited weak associations with the similarity scores for the original PD, but these were not statistically significant.

## Discussion

To our knowledge, this is the first study to evaluate whether people with CNP can recognize their own PD among distorted versions of their original PD. The results confirm that the patients with CNP were largely capable of detecting their own PD, suggesting that they have an intact body structural description. They also displayed consistency in recognizing their own original PD in both trials when presented in a random order among the other modified PDs. This consistency helps rule out the probable chance of guess by the patients, supporting the reliability of the results. The patients rated the same degree of similarity when the PD was scaled down to 75% and scaled up by 150% of the original size; thus when the distortion was minimal. They were also able to determine the dissimilarity in the PDs when the PD was modified more substantially by horizontal or vertical translation, unlike when it was downscaled or upscaled, suggesting that their perception was more tuned to location than extent. The ability to recognize their pain was negatively associated with their MSPQ scores indicating greater difficulty in those with more marked somatic symptoms or more "nonorganic" elements to their presentation.

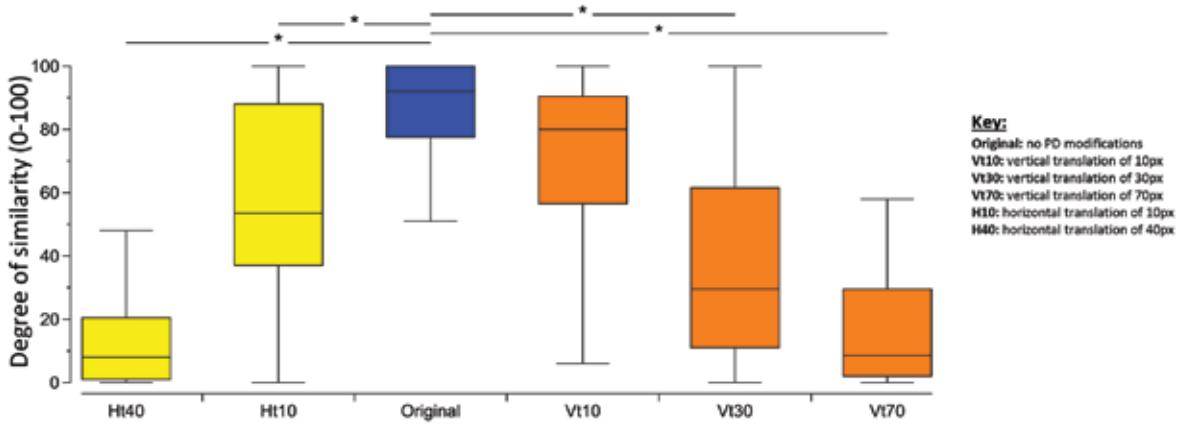


Fig. 4. *Box plots illustrating similarity scores (y-axis) reported for the original PD, vertically (Vt) and horizontally (Ht) translated PDs (x-axis). *indicates a significant difference $P < 0.05$.*

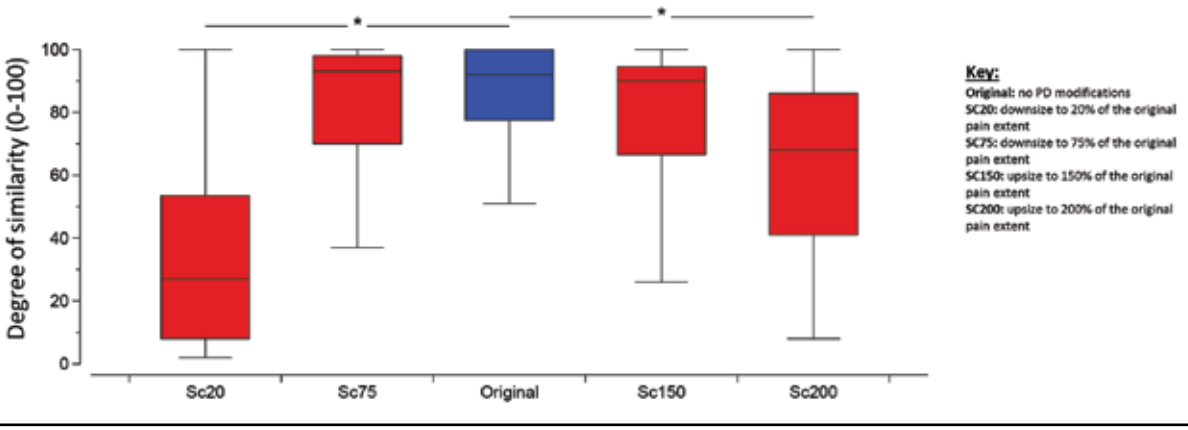


Fig. 5. *Box plots demonstrating similarity scores (y-axis) reported for the original PD, downscaled (Sc 20, Sc 75) and upscaled (Sc 150, Sc 200) modified PDs (x-axis). *indicates a significant difference $P < 0.05$.*

This study provides novel insight into the perception of pain location, pain extent, and self-awareness among individuals with CNP. There is evidence of reduced proprioceptive acuity (14), altered motor control strategies (17,28), and maladapted pain cognitions (29) among people with CNP, and although these features were not examined in the current population, these factors, if present, do not appear to disrupt their ability to recognize their own PD. Other studies have shown that patients with CRPS and phantom limb pain perceive their painful or phantom limb as being bigger than it really is, whereas patients with back pain reported that the part felt smaller than it should be (1); however, these patient populations typically present with more severe pain than those included in the current study.

The patients were able to identify major changes in size of their painful area, as displayed in Fig. 5, with significantly different similarity scores for PDs that were downscaled to 20% or upscaled to 200%. However, when only the more subtle modifications were made, such as when the PD was scaled down to 75% and up scaled by 150% of the original size, the patients were able to identify greater similarity to their own PD. Differences in scoring the PDs when they were either horizontally or vertically translated versus downscaled or upscaled may also be related to pain memory, which

Table 2. *Results of the Spearman correlation between similarity scores of the original PDs and clinical features.*

| | rs | *P* value |
|---|---|---|
| Age | 0.002 | 0.993 |
| Pain duration | 0.184 | 0.451 |
| Pain<br>NRS-11 | –0.364 | 0.126 |
| Disability<br>NDI | –0.067 | 0.786 |
| DASS<br>Depression<br>Anxiety<br>Stress | <br>0.128<br>–0.286<br>–0.227 | <br>0.603<br>0.234<br>0.349 |
| PCS<br>Rumification<br>Magnification<br>Helplessness | <br>–0.384<br>–0.324<br>–0.189 | <br>0.104<br>0.176<br>0.439 |
| Somatic aspect<br>MSPQ | <br>–0.470* | <br>0.037 |

Abbreviation: NDI, Neck Disability Index.
*Significant, $P < 0.05$.

could have a higher accuracy for location, especially in the horizontal direction with respect to its extension (30,31).

In the current study, we found that the ability of an individual with CNP to recognize their own pain was significantly associated with their degree of somatic awareness. Previous studies have shown that people with chronic pain exhibit heightened somatic awareness (27), which interferes with their cognitive function (29) and attention (30), which contributes to an individual's awareness by controlling the selection of information (32). Patients with back pain with greater somatic awareness were found to exhibit more difficulty in driving their attention away from their pain than those with somatic awareness (33).

### Clinical Implications

There is evidence that people with chronic pain tend to perceive their painful area/body part as enlarged or reduced in size (34,35). This may reflect difficulty rescaling the pain on a model that is much smaller than the real body. Interventions targeting the sensorimotor cortex in people with chronic pain have shown positive results, with a reduction in pain intensity, as well as enhanced cortical representation of the affected area (36-38). The current results may prompt clinicians to evaluate pain perception and somatic awareness in people with CNP, which could highlight the need for more specific, targeted interventions in some patients. The results also provide confidence in having patients use PDs to document the spatial location and extent of their pain.

### Strengths and Limitations

The modifications of the PD were generated with specific dimensions using a novel software, providing us with an objective range of distortion and eliminating errors, which could potentially occur in manually controlled visual-subjective based methods. Although, the results show that individuals with CNP identified an enlarged or shrunken PD as their own PD, the results cannot be generalized to a wider population as the sample size in our study included a small convenience sample of people with relatively mild CNP.

## Conclusions

When presented with their original PD among a number of distorted versions of their PD, people with CNP rated their original PD with the highest degree of similarity, which supports the use of the PD as a clinical tool to represent the pain experience of patients. Those with more marked somatic symptoms had the greatest difficulty recognizing their own original PD.

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