

## Lower-Order Pain-Related Constructs Are More Predictive of Cold Pressor Pain Ratings than Higher-Order Personality Traits

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**Abstract:** Pain is a debilitating condition affecting millions each year, yet what predisposes certain individuals to be more sensitive to pain remains relatively unknown. Several psychological factors have been associated with pain perception, but the structural relations between multiple higher- and lower-order constructs and pain are not well understood. Thus, we aimed to examine the associations between pain perception using the cold pressor task (CPT), higher-order personality traits (neuroticism, negative affectivity, trait anxiety, extraversion, positive affectivity, psychoticism), and lower-order pain-related psychological constructs (pain catastrophizing [pre- and post-], fear of pain, anxiety sensitivity, somatosensory amplification, hypochondriasis) in 66 pain-free adults. Factor analysis revealed 3 latent psychological variables: pain- or body-sensitivity, negative affect/neuroticism, and positive affect/extraversion. Similarly, pain responses factored into 3 domains: intensity, quality, and tolerance. Regression and correlation analyses demonstrated that: 1) all the lower-order pain constructs (fear, catastrophizing, and hypochondriasis) are related through a single underlying latent factor that is partially related to the higher-order negative-valence personality traits; 2) pain- or body-sensitivity was more strongly predictive of pain quality than higher-order traits; and 3) the form of pain assessment is important—only qualitative pain ratings were significantly predicted by the psychological factors.

**Perspective:** Consistent with the biopsychosocial model, these results suggest multiple pain-related psychological measures likely assess a common underlying factor, which is more predictive of qualitative than intensity pain ratings. This information may be useful for the development and advancement of pain assessments and treatments while considering the multidimensional nature of pain.

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**Key words:** Experimental pain, neuroticism, pain catastrophizing, fear of pain, anxiety sensitivity, somatosensory amplification.

Pain is a significant health concern with considerable economic and emotional costs. In the United States, pain accounts for 80% of all physician visits<sup>25</sup> and 10% of Americans experience pain 100 days or longer annually.<sup>48</sup> However, pain perception can vary greatly between individuals.<sup>21</sup> According to the biopsychosocial model, individual differences in pain sensitivity may be explained by the interaction between physiological, psychological, and social variables.<sup>65</sup> Consistent with this theory, certain psychological factors are increasingly rec-

ognized as playing a role in pain perception. For example, significant associations have been observed between clinical pain and lower-order, pain-related constructs including pain catastrophizing,<sup>27,28</sup> fear of pain,<sup>9,43</sup> anxiety,<sup>42,47,50</sup> anxiety sensitivity,<sup>2,39</sup> and somatosensory amplification.<sup>31,55</sup> Neuroticism/negative affectivity, a broad, higher-order trait associated with negative emotions, cognitions, and self-concept,<sup>18,70</sup> also is correlated with symptom severity in some chronically painful conditions.<sup>1,29</sup>

In patients, however, it is unclear whether baseline personality characteristics influence pain perception or whether the pain experience may alter self-report personality measurement. Indeed, personality scores can change (ie, improve) following successful chronic pain treatment.<sup>23</sup> While informative, clinical samples rarely are able to assess baseline psychological variables in the absence of pain. Experimental pain studies involving healthy

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individuals, although lacking in regard to dimensions of the chronic pain experience (eg, duration, pathology, comorbidities), allow aspects of acute pain to be investigated relative to baseline psychological characteristics.

The cold pressor task (CPT) is a common model used to investigate individual differences.<sup>11,26,63</sup> Numerous associations between CPT pain and a variety of lower-order psychological constructs have been reported, including negative mood,<sup>24</sup> pain catastrophizing,<sup>11,63</sup> fear of pain,<sup>26,57</sup> anxiety,<sup>19,35</sup> anxiety sensitivity,<sup>40,57</sup> and emotional vulnerability.<sup>11,63</sup> Relatively few studies have assessed traditional higher-order personality traits, with mixed results. Negative or positive affect did not relate to pain intensity<sup>62</sup> or tolerance,<sup>60</sup> whereas extraversion correlated with pain tolerance in 2 studies.<sup>19,54</sup> To our knowledge, several potential higher- and lower-order traits (eg, neuroticism, psychoticism, somatosensory amplification, and hypochondriasis) have not been assessed with experimental pain in a healthy sample.

The underlying structure relating lower-order, pain-related constructs, and stable personality traits is unclear. Numerous personality theories have been proposed over the years, with varying trait names (eg, extraversion, positive emotionality, surgency) and structures ranging from 2- to 16-factor models. However, personality structure is now generally conceived as a hierarchical model, with broad higher-order factors (eg, neuroticism, extraversion) at the top, and narrower, more specific lower-order factors facets or dimensions (eg, fear, hostility) below.<sup>13,41,77</sup> It is unknown whether lower-order, pain-related constructs are simply facets of higher-order traits (eg., neuroticism or negative affect) or distinct dimensions of personality. Certainly, the associations between pain and isolated lower-level constructs may be attributable to neuroticism, or due to another underlying latent construct.<sup>65,71</sup>

Measuring multiple levels of personality is necessary to disentangle the underlying hierarchical structure and the potential relative contributions of psychological factors to pain perception.<sup>71</sup> Few studies have investigated the roles and interactions of multiple higher- and lower-order traits and constructs on pain perception in 1 cohort. Thus, the primary purposes of this study were: 1) to investigate the structure of higher-order personality traits and lower-order, pain-related constructs; and 2) to assess their relation to experimentally induced CPT pain sensitivity. Traditional higher-order traits (eg, neuroticism, negative affect, trait anxiety, extraversion, positive affect, and psychoticism) and 3 primary lower-order domains (catastrophizing, fear/anxiety sensitivity, and somatosensory amplification/hypochondriasis) were assessed. Multiple pain measures were considered, including pain quality and intensity, threshold, tolerance, and inhibitory processes (diffuse noxious inhibitory controls [DNIC]).

## Methods

### Participants

Sixty-six healthy, pain-free volunteers were recruited from the local and university community. Thirty-three

males (mean age  $30.1 \pm 11.5$  years) and 33 females (mean age  $29.7 \pm 11.4$  years) participated in the study; overall mean (SD) age was 29.9 (11.3), and the age range was 18 to 55 years. Reported race and ethnicity was 80% Caucasian, 11% Asian, and 9% Hispanic. Approximately 8% of the participants were physical-therapy graduate students; thus, this small subset may have been familiar with cold application. However, the remaining cohort likely had no special training with cold application techniques. Exclusion criteria included: significant current or past medical conditions (eg, diabetes, asthma, heart disease), pregnancy, current pain, history of chronic pain, prescription analgesics or medications other than birth control or vitamins, Raynaud's Syndrome or Urticaria (cold-sensitivity and hives), elevated blood pressure (150/100 or greater), previous or current loss of sensation or feeling in the arms or legs, and previous major hand or arm injury or surgery. All participants provided written informed consent prior to participation, as approved by the University of Iowa Biomedical Institutional Review Board, and were compensated for their time.

### Cold Pressor Task

Participants submerged their nondominant hand to the wrist in a cold water bath maintained at approximately 0°C, monitored and recorded for each participant. Water was circulated continuously to maintain target water temperature and avoid heat buildup around the hand.<sup>46,74</sup> The forearm was supported using a soft armrest to keep the hand at a constant immersion depth and for comfort, allowing the participant to relax the limb during the test. Participants were asked to keep their hand immersed in the water bath for as long as they could, and to report when the sensation first became painful (approximately a 1 ["light pain"] out of 10 on the Borg NRS scale) by saying "pain" (ie, pain threshold). They were also instructed that if the pain became intolerable, they could remove their hand at any time without penalty (ie, pain tolerance). Immersion time was measured on a stopwatch held outside of the participants' view, with an uninformed maximum immersion time of 5 minutes for safety.

### Pain Measures

#### Pain Threshold and Tolerance

Pain threshold and tolerance during the CPT were assessed as the time to first pain (seconds; see CPT description above) and time to hand withdrawal (seconds) as measured by a hand-held stopwatch.

#### Borg CR10 Numeric Pain Rating Scale

Participants were asked to verbally rate their CPT peak pain intensity immediately following the task using the Borg Category Ratio 0 to 10 numeric pain-rating scale (Borg NRS). The Borg NRS provides a quantitative measure of pain intensity with category anchors: 0 indicating "No Pain," 1 "Light Pain," 3 "Moderate," 5 "Strong," and 10 "Max Pain." Pain ratings higher than "10" are also possible, eliminating the ceiling effect. A written script,

modified from Borg (1998), was read to each participant to ensure consistent instructions for scale use. The Borg NRS has been validated with VAS pain ratings during passive joint loading ( $r = .78$  to  $.99$ ),<sup>32</sup> muscle-ache during an arm-cranking exercise ( $r = .99$ ),<sup>5</sup> and exercise-induced muscle pain.<sup>8</sup>

### Electronic Visual Analog Scale

Participants were instructed to rate their pain intensity continuously during the CPT using a 0 to 10-cm electronic Visual Analog Scale (eVAS) with word anchors indicating "No Pain" and "Worst Pain Imaginable" on the left and right ends, respectively. Peak eVAS pain-intensity ratings were extracted for each participant, with verbal reminders to ensure that ratings were updated at a minimum of every 15 to 20 seconds. Pain ratings were recorded electronically on a laptop computer (50 Hz sampling rate) to the nearest millimeter. The VAS is the most commonly used clinical and experimental pain-assessment tool due to its simplicity, efficiency,<sup>53</sup> and ability to detect small differences in ratings;<sup>33</sup> eVAS measures are valid and reliable for assessing pain perception.<sup>36</sup>

### Short-Form McGill Pain Questionnaire

The short-form McGill Pain Questionnaire (MPQ)<sup>45</sup> is comprised of 3 subscales, providing both qualitative and quantitative pain assessments. Participants rated their pain on a 15-adjective verbal descriptor pain scale with 11 items reflecting sensory and 4 items reflecting affective pain dimensions; each adjective was rated as "none," "mild," "moderate," or "severe." The MPQ total score was the sum of the 15 pain descriptor item responses. Participants then rated their overall pain intensity using a 10-cm horizontal VAS anchored from "no pain" to "worst possible pain." Finally, participants endorsed their CPT pain using a 6-point evaluative scale (Present Pain Index [PPI]) ranging from "no pain" to "excruciating." The first and third scales consist of qualitative, verbal descriptor scales, whereas the VAS provides a quantitative pain-intensity scale. Three MPQ scores were considered in the analyses: the MPQ total score (sum of the sensory and affective subscales), the VAS (to the nearest mm), and the PPI score. The short-form MPQ is a reliable<sup>76</sup> and valid instrument.<sup>14,45</sup>

### Pressure Pain Thresholds

Pressure pain threshold (PPT) is defined as the amount of force needed to elicit a sensation of pain distinct from pressure<sup>22</sup> and was assessed using a hand-held digital pressure algometer (Somedic AB, Farsta, Sweden). The mean of 2 PPT repetitions were recorded for baseline (pre-CPT) and immediately following the cold pressor task (~3 to 4 minutes post-CPT) at 4 locations outside of the immersed region: the ipsilateral forearm of the test limb and 3 locations contralaterally; the thenar eminence, inside of the middle distal phalanx of the hand, and the forearm. The algometer was applied perpendicularly using a 1-cm<sup>2</sup> tip at a rate of approximately 30 kPa/s until the pain threshold was reached, with threshold

defined as approximately a 1 ("light pain") out of 10 on the Borg NRS scale. The 4 locations were averaged to obtain a mean PPT score, standardized by their respective baseline values (% PPT). Deep-tissue mechanical hyperalgesia (increased pain sensitivity) was operationally defined as less than 100%, whereas hypoalgesia (decreased pain sensitivity) was operationally defined as greater than 100%. This measure demonstrates good reliability.<sup>7,58</sup>

### Higher-Order Personality Measures

The Eysenck Personality Questionnaire-Revised (EPQ-R)<sup>18</sup> is a 100-item self-report instrument containing 4 scales- psychoticism (disinhibition or toughmindedness), extraversion, neuroticism, and lie. Higher scores on the neuroticism scale (N) indicate an anxious, worrisome, overly emotional, and somewhat rigid personality. A higher score on the extraversion scale (E) indicates a sociable, optimistic, excitement-craving, easy-going personality. Higher scores on the psychoticism scale (P) indicate a disinhibited, hostile and nonconformist personality.<sup>18</sup> The EPQ-R scales have demonstrated good internal consistency and test-retest reliability.<sup>18</sup> The Lie scale was not used in this study.

The Positive and Negative Affect Schedule (PANAS)<sup>74</sup> is a valid and reliable self-report measure of positive (PA) and negative affect (NA)<sup>73</sup> The scale consists of 20 single mood descriptors, 10 per scale. Participants rate each word (eg, "interested," "distressed") in terms of the extent to which they "generally feel this way, that is, on the average" (ie, general trait instructions) on a 5-point scale ranging from "very slightly or not at all" to "extremely."

Trait anxiety (TA) was measured using the State-Trait Anxiety Inventory (STAI),<sup>61</sup> a self-report measure of anxiety-proneness with excellent internal consistency and reliability.<sup>3</sup> Participants rate their general (dispositional) agreement with each statement ("I am tense") on a 4-point Likert scale. The state anxiety scale was not used in this study.

### Lower-Order Pain-Related Measures

Two fear-related measures were assessed. Pain-related fear was measured using the Fear of Pain Questionnaire (FPQ), consisting of 30 self-report items, with good reliability and consistency.<sup>44</sup> Participants rate their anticipated fear of the pain associated with each event on a 5-point Likert scale. The FPQ contains 3 subscales that were summed to create a single FPQ score: 1) severe pain; 2) minor pain; and 3) medical pain. Anxiety-related fear was measured using the Anxiety Sensitivity Index (ASI),<sup>56</sup> a 16-item self-report instrument with good test-retest reliability<sup>40,55</sup> and internal consistency.<sup>68</sup> Statements are rated on a 5-point Likert scale.

Pain catastrophizing was assessed both at baseline (pre-PCS) using recall of past pain experiences and immediately following the CPT, focusing on the CPT pain experience (post-PCS), using the Pain Catastrophizing Scale (PCS).<sup>62</sup> Thorn et al<sup>63</sup> suggest that pain-related catastrophizing during the cold pressor task (ie, situational)

may be more correlated with pain reports than generalized (ie, dispositional) pain catastrophizing assessed a priori.<sup>11,16</sup> This 13-item self-report instrument assesses the extent to which individuals experience different thoughts and feelings when in pain, using a 5-point Likert scale. The PCS total score is the sum of its 3 subscales: 1) rumination; 2) magnification; and 3) helplessness.

Somatic sensitivity was assessed with 2 measures as well. The Somatosensory Amplification Scale (SSAS)<sup>4</sup> is a 10-item self-report measure of sensitivity to a range of normal bodily sensations (eg, "I hate to be too hot or too cold") using a 5-point scale. The SSAS demonstrates good internal consistency and test-retest reliability.<sup>4</sup> The Whiteley Index (WI) is a 14-item self-report measure of hypochondriacal worries and beliefs using a 5-point Likert scale. The WI has good internal consistency and test-retest reliability.<sup>51</sup>

## Procedures

All participants completed 1 session lasting approximately 1 hour. After providing written informed consent, participants' blood pressure was measured to ensure study criteria were met. Participants then completed 8 baseline psychological measures: 1) Eysenck Personality Questionnaire-Revised; 2) Positive and Negative Affect Schedule; 3) Trait Anxiety Inventory; 4) Pain Catastrophizing Scale (pre-PCS); 5) Fear of Pain Questionnaire; 6) Somatosensory Amplification Scale; 7) Anxiety Sensitivity Index; and 8) Whiteley Index. The order of the scales was block-randomized to minimize order or testing-fatigue effects. Baseline PPTs were then measured at the 4 locations. All participants immersed their nondominant hand to the wrist in a bucket of warm water (~34°F) for 5 minutes to normalize the starting hand temperature, followed by the CPT using the nondominant hand. Participants rated their pain intensity continuously on the eVAS using their dominant hand. Immediately after the CPT, participants rated their peak pain intensity during the cold water immersion verbally using the Borg NRS scale. Participants completed the MPQ and the PCS a second time (post-PCS) with instructions to consider the CPT they just experienced (order randomized between the MPQ and post-PCS). Post-CPT PPTs were then assessed. A female experimenter conducted all procedures.

## Analyses

Descriptive statistics were determined for each study variable, including separate means and standard deviations for women and men. To determine if sample distributions were approximately normal, the Kolmogorov-Smirnov test was used. Independent samples *t*-tests were conducted for each pain and psychological measure to test for significant differences between women and men. Associations among the pain and psychological variables were assessed using Pearson's product-moment correlation coefficients. In addition, factor analyses were used to examine the latent factor structure of the pain and psychological variables and to reduce the total number of variables investigated. Factors were extracted

Pain-Related Constructs Predict Cold-Pressor Pain using Principal Axis Factoring with varimax rotation (v16.0; SPSS, Chicago, IL); the number of retained factors was determined by examining the scree plot<sup>6</sup> and by considering the clarity/interpretability of the rotated solutions. Regression-based factor scores were then used to calculate latent variables based on the variable loading coefficients for each factor. These latent variables were named for clarity according to the primary variables loading on each factor. Associations between latent pain and psychological factors were also assessed using Pearson's product-moment correlation coefficients. Regression analyses were then used to assess how well each latent pain variable was predicted by the latent psychological variables, controlling for sex. Standardized beta coefficients and  $R^2$  values are reported for each model. Significance was set at an alpha level of  $P = .05$ , unless otherwise noted.

## Results

Summary statistics for all psychological and pain variables are listed in Table 1. Seventeen participants reached the 5 minute uninformed maximum time (12 males, 5 females), and were asked to remove their hand (5-minute tolerance assigned). All psychological and pain-related measures were within expected population-based norms and approximately normally distributed.

## Pain Measures

The cold pressor task induced moderate to severe pain in most individuals with overall mean (SD) peak pain ratings of 7.5 (2.2) and 7.3 (1.8) for the eVAS and the written VAS, respectively. Threshold and intensity pain measures did not differ between women and men (Table 1); tolerance time was significantly longer for men, even with the uninformed limit (Table 1). PPTs significantly increased (indicating reduced pressure pain sensitivity) following the CPT at all 4 locations, with no significant between-site differences ( $F_{3, 192} = 1.33, P = .27$ ). The bilaterally elevated % PPTs indicate diffuse hypoalgesia, evidence of DNIC processes, with no observed sex differences (Table 1).

Correlations among the pain rating scales ranged from  $r = .18$  to  $.84$  (Table 2). The predominantly quantitative pain intensity measures (ie, Borg NRS, peak eVAS, VAS) were highly correlated ( $r = .66$  to  $.84, P < .01$ ) and the qualitative pain descriptor scales (ie, MPQ total and PPI) were significantly correlated ( $r = .52, P < .01$ ). However, associations between the quantitative and qualitative pain ratings were more variable, ranging from  $r = .18$  to  $.62$ .

CPT pain threshold and tolerance times were significantly positively correlated ( $r = .45, P < .01$ ). Pain threshold was only correlated with 1 pain measure, the PPI ( $r = -.32, P < .05$ ), indicating lower thresholds were associated with higher PPI ratings. Tolerance time was significantly negatively correlated with the Borg NRS ( $r = -.33, P < .01$ ), VAS ( $r = -.31, P < .05$ ), and PPI ( $r = -.47, P < .01$ ), indicating high pain ratings were associated with shorter CPT immersions on 3 of the 5 possible scales.

**Table 1. Summary Statistics for Personality and Pain Variables (Mean, SD) by Sex (N = 66)**

	FEMALES	MALES	TOTAL	P VALUE
Age (yrs)	30.1 (11.5)	29.7 (11.4)	29.9 (11.3)	.87
Height (cm)*	167.1 (6.9)	180.0 (5.6)	173.1 (8.6)	<.001
Weight (kg)*	68.19 (12.2)	77.8 (10.6)	73.1 (12.3)	.001
Neuroticism (0–24)	9.5 (4.4)	8 (5.0)	8.8 (4.7)	.22
Negative Affect (10–50)	15.0 (3)	15.8 (4.8)	15.4 (4)	.43
Trait Anxiety (20–80)	33.3 (8.3)	32.8 (8.9)	33.0 (8.5)	.84
Pre-Pain Catastrophizing (0–52)	10.9 (7.6)	14.1 (8.7)	12.5 (8.3)	.12
Post-Pain Catastrophizing (0–52)	15.0 (9.8)	16.0 (13.1)	15.5 (11.5)	.72
Fear of Pain (30–150)	75.6 (16.6)	73.7 (17.9)	74.6 (17.1)	.66
Anxiety Sensitivity (0–64)	14.7 (7.1)	14.8 (7.9)	14.7 (7.4)	.96
Somatosensory Amplification (10–50)	25.4 (5.4)	24.4 (5.6)	24.9 (5.5)	.45
Whiteley Index (14–70)	19.9 (5.6)	20.8 (5.6)	20.4 (5.6)	.52
Psychoticism (0–33)	5.7 (3.18)	6.6 (3.29)	6.1 (3.24)	.29
Extraversion (0–22)	15 (5.41)	14.3 (5.61)	14.7 (5.48)	.63
Positive Affect (10–50)	35.8 (5.85)	36.1 (5.48)	36 (5.62)	.81
CPT Pain Threshold (sec)	15.8 (14.06)	15.9 (10.67)	15.9 (12.4)	.98
CPT Tolerance (sec) (0–300)*	101.9 (96.8)	181 (112.7)	141.4 (111.6)	.003
Borg NRS (0–10)	6.9 (1.9)	7 (1.8)	7 (1.8)	.87
Peak eVAS (cm) (0–10)	7.5 (2.2)	7.4 (2.2)	7.5 (2.2)	.56
VAS (cm) (0–10)	7.3 (1.8)	7.3 (1.9)	7.3 (1.8)	.94
MPQ Total (0–45)	10.6 (6.3)	13.5 (7)	12.1 (6.8)	.08
PPI (0–5)	3 (.8)	3.1 (.9)	3.1 (.8)	.66
PPT (%)	111.4 (16.6)	109.1 (17.5)	110.2 (17)	.59

Abbreviations: NRS, 0-10 numeric rating scale; eVAS, electronic Visual Analog Scale; VAS, short-form McGill Pain Questionnaire (MPQ) Visual Analog Scale; MPQ total, MPQ total score; PPI, MPQ Present Pain Index; PPT, mean standardized PPT scores.  
 \*Significant difference between females and males.

Neither threshold nor tolerance times were correlated with the MPQ total score ( $r = -.19$  to  $-.05$ ,  $P > .13$ ) or peak eVAS score ( $r = -.11$  to  $-.14$ ,  $P > .27$ ).

Three distinct latent pain-response factors (Table 3) explained 59.1% of the total variance observed in the 8 pain measures. The first factor primarily was defined by the quantitative intensity pain measures, and thus is described as the Intensity Factor. The second factor was most strongly marked by the tolerance time, but with moderate loadings on threshold time and the inverse of the PPI rating, and is referred to as the Tolerance Factor. The third factor loaded most strongly with the MPQ total score and the PPI, and is referred to as the Qualitative Factor. Both the tolerance and qualitative latent pain factors significantly differed between women and men ( $P = .005$  and  $.013$ , respectively), but the intensity factor did not ( $P = .95$ ). The relative

change in PPTs (DNIC response) did not load with any of the 3 latent pain-response factors. Similarly, the DNIC response (% PPT) did not significantly correlate with any of the other pain responses ( $r = -.05$  to  $.15$ ;  $P = .23$  to  $.96$ ).

### Psychological Measures

Correlations between the higher- and lower-order personality variables are presented in Table 4. The higher-order, negative valence traits (neuroticism, negative affect, trait anxiety) were highly correlated with each other ( $r \geq .70$ ,  $P < .01$ ). Similarly, the 2 higher-order, positive valence traits (extraversion, positive affect) were positively correlated with each other and negatively correlated with N, NA, and TA. Psychoticism (disinhibition) was not correlated with the remaining higher-order traits.

**Table 2. Pearson’s Correlation Coefficients Between Pain Variables**

	THRESHOLD	TOLERANCE	BORG NRS	eVAS	VAS	MPQ	PPI
Tolerance	.45†	—					
Borg NRS	-.22	-.33†	—				
eVAS	-.11	-.14	.66†	—			
VAS	-.22	-.31*	.76†	.84†	—		
MPQ	-.19	-.05	.18	.35†	.43†	—	
PPI	-.32*	-.47†	.39†	.62†	.56†	.52†	—
% PPT	-.05	.01	.01	.15	.04	-.03	-.03

Abbreviations: NRS, 0-10 numeric rating scale; eVAS, electronic Visual Analog Scale; VAS, short-form McGill Pain Questionnaire (MPQ) Visual Analog Scale; MPQ, MPQ total score; PPI, MPQ Present Pain Index; PPT, mean standardized PPT scores.

\* $P \leq .05$ .

† $P \leq .01$ .

**Table 3. Pain Variable Factor Loadings Using Principal Axis Factoring With Varimax Rotation**

NAME	FACTOR 1	FACTOR 2	FACTOR 3
	INTENSITY	TOLERANCE	QUALITATIVE
VAS	.83*	-.23	.35
Peak eVAS	.83*	-.06	.07
Borg NRS	.75*	-.28	.33
Tolerance	-.10	.95*	.03
Threshold	-.07	.46*	-.16
MPQ	.15	-.07	.74*
PPI	.35	-.46*	.56*
%PPT	.12	.01	-.09

Abbreviations: NRS, 0-10 numeric rating scale; eVAS, electronic Visual Analog Scale; VAS, short-form McGill Pain Questionnaire (MPQ) Visual Analog Scale; MPQ, MPQ total score; PPI, MPQ Present Pain Index; PPT, mean standardized PPT scores.

\*Factor loadings >.4.

The lower-order constructs (pre- and post-pain catastrophizing, fear of pain, anxiety sensitivity, somatosensory amplification, hypochondriasis) were consistently intercorrelated ( $r = .25$  to  $.62$ ,  $P < .05$ , Table 4). All of the lower-order constructs were significantly correlated with at least one of the higher-order, negative valence traits (neuroticism, negative affect, trait anxiety), with 4 of the 6 constructs being correlated to all 3 of the higher-order traits (Table 4). None of the lower-order traits were correlated with either psychoticism or extraversion, but somatosensory amplification, pre-pain catastrophizing, and anxiety sensitivity were negatively correlated with positive affect ( $r = -.28$  to  $-.37$ ,  $P < .05$ ). No significant sex differences were noted for any of the psychological measures (Table 1).

Three latent factors were extracted from the 12 personality and pain-related construct variables, explaining a total of 51.5% of the response variance (Table 5). Only 1 factor emerged for all of the lower-order pain-related constructs (Factor 1, Table 5); thus, it was labeled as Pain or Body Sensitivity for simplicity. Pain catastrophizing (pre-PCS), anxiety sensitivity, and hypochondriasis were the 3 highest loadings on the latent Pain or Body

Pain-Related Constructs Predict Cold-Pressor Pain Sensitivity Factor. Both neuroticism and negative affect also had moderate loadings on this factor. The second and third factors are termed Negative Affect/ Neuroticism and Positive Affect/ Extraversion, respectively, based on their highest loadings (Table 5). Somewhat surprisingly, both trait anxiety and neuroticism loaded on both Factors 2 and 3. Psychoticism did not load highly on any of the 3 latent psychological factors. No sex differences were observed for any of the 3 latent psychological variables ( $P = .56$  to  $.64$ ).

## Pain and Psychological Measures

Correlations between the latent pain and psychological factors are presented in Table 6. Only the Pain Qualitative Factor was significantly correlated with the Pain or Body Sensitivity Factor. Regression models were then used to predict the 3 latent pain response variables, controlling for sex (Table 7). The first latent pain factor (Intensity) was not significantly predicted by the model ( $P = .26$ ). The second latent pain factor (Tolerance) was significantly predicted by the model ( $P = .03$ ), but only sex was a significant predictor ( $P = .008$ ). The third latent pain factor (Qualitative) was also significantly predicted by the model ( $P < .0001$ ); Pain or Body Sensitivity was the strongest predictor even when controlling for sex ( $P < .001$ ).

## Discussion

This study demonstrates that lower-order, pain-related constructs are interrelated, correlate with neuroticism and negative affect, and predict CPT pain quality. All of the currently measured lower-order constructs (pre- and post-pain catastrophizing, fear of pain, anxiety sensitivity, somatosensory amplification, and hypochondriasis), along with negative affect and neuroticism, loaded on a single underlying latent factor, termed Pain or Body Sensitivity. Of the 3 latent pain factors (Intensity, Tolerance, and Qualitative Pain), only pain quality was significantly predicted by the latent Pain- or Body Sensitivity Factor. These results suggest that: 1) multiple pain-related constructs are related to qualitative pain by

**Table 4. Pearson's Correlation Coefficients Between Personality Traits and Pain-Related Constructs**

	N	NA	TA	PA	E	P	PRE-PCS	POST-PCS	FP	AS	SSA
NA	.70†	—									
TA	.72†	.73†	—								
PA	-.40†	-.28*	-.63†	—							
E	-.26*	-.20	-.36†	.47*	—						
P	-.01	.13	.05	.05	.07	—					
Pre-PCS	.49†	.60†	.48†	-.37†	-.20	-.15	—				
Post-PCS	.22	.43†	.23	-.14	-.18	-.11	.53†	—			
FP	.21	.36†	.21	-.14	.07	-.13	.38†	.31*	—		
AS	.38†	.50†	.38†	-.28*	-.11	-.10	.57†	.44†	.49†	—	
SSA	.35†	.29*	.32†	-.28*	-.03	-.20	.45†	.33†	.40†	.39†	—
WI	.46†	.41†	.30*	-.18	.05	-.07	.62†	.25*	.29*	.53†	.41†

Abbreviations: N, Neuroticism; NA, Negative Affect; TA, Trait anxiety; PA, Positive Affect; E, Extraversion; P, Psychoticism; Pre-PCS, Pre-task Pain Catastrophizing; Post-PCS, Post-task Pain Catastrophizing; FP, Fear of Pain; AS, Anxiety Sensitivity; SSA, Somatosensory Amplification; WI, Whiteley Index.

\* $P \leq .05$ .

† $P \leq .01$ .

**Table 5. Psychological Variable Factor Loadings Using Principal Axis Factoring With Varimax Rotation**

NAME	FACTOR 1	FACTOR 2	FACTOR 3†
	PAIN- OR BODY SENSITIVITY	NEGATIVE AFFECT/ NEUROTICISM	POSITIVE AFFECT/ EXTRAVERSION
Pre-PCS	.77*	.12	-.28
ASI	.71*	.10	-.14
WI	.64*	.16	-.04
SSA	.60*	-.06	-.18
FPQ	.57*	.01	.01
Post-PCS	.53*	.03	-.11
NA	.55*	.74*	-.25
N	.43*	.50*	-.42*
TA	.32	.53*	-.67*
PA	-.20	-.01	.79*
E	.01	-.02	.59*
P	-.21	.33	.07

Abbreviations: N, Neuroticism; NA- Negative Affect; TA, Trait Anxiety; PA, Positive Affect; E, Extraversion; P, Psychoticism; Pre-PCS, Pre-task Pain Catastrophizing; Post-PCS, Post-task Pain Catastrophizing; FP, Fear of Pain; AS, Anxiety Sensitivity; SSA, Somatosensory Amplification; WI, Whiteley Index.

\*Factor loadings > .4.

†Indicates factor loading coefficients are reversed keyed.

a single underlying latent factor; and 2) the relations between pain and psychological factors vary across different types of pain assessments.

The lower-order, pain-related constructs were most strongly correlated to neuroticism, negative affect, and trait anxiety. This is consistent with prevailing notions regarding the hierarchical structure of personality, wherein neuroticism is thought to encompass a range of subfactors, including fear, hostility, guilt, anger, anxiety, and stress reactivity.<sup>72</sup> Research demonstrates that various measures of negative affect and neuroticism are tapping into a common factor structure,<sup>70,71</sup> with moderate to strong associations being observed between neuroticism and measures of negative mood<sup>1,10</sup> and trait anxiety.<sup>70</sup>

Although each lower-order, pain-related construct was chosen as a measure of a specific domain (eg, fear/anxiety, somatic sensitivity, or catastrophizing), they were moderately to strongly intercorrelated and loaded on a single latent factor, along with negative affect and neuroticism. Significant correlations between several of these lower-order constructs have been reported.<sup>26,49,62</sup> The observation of 1 underlying latent factor suggests although these instruments may assess distinct domains, they are not independent, rather they are related in a meaningful way.

The various pain responses assessed in this study factored into 3 distinct domains: intensity, quality, and tolerance. These findings are congruent with Price's classic research demonstrating that experimental and clinical pain consist of both sensory and affective dimensions, such as intensity and unpleasantness.<sup>53</sup> Whereas qualitative indices assess the unpleasant nature of pain, quantitative measures assess the sensory-discriminative component of pain.<sup>45</sup> The latent pain factor we termed Qualitative may be similar to Price's affective dimension

**Table 6. Pearson's Correlation Coefficients Between Latent Pain and Psychological Factors**

PAIN FACTORS	PSYCHOLOGICAL FACTORS		
	PAIN- OR BODY SENSITIVITY	NEGATIVE AFFECT	POSITIVE AFFECT
Intensity	.18	-.14	-.16
Tolerance	-.06	.14	-.15
Qualitative	.45†	.05	.01

†P ≤ .01.

of unpleasantness. The Pain Tolerance Factor included threshold, but was distinct from either the pain intensity or quality factors. This is consistent with previous findings which have shown a tolerance or pain endurance factor as independent of pain intensity.<sup>64,75</sup> PPI loaded primarily on the Qualitative Factor, but loaded secondarily on the Tolerance Factor. This may suggest the descriptor options for the PPI (eg, "distressing" or "excruciating") tap into cognitions associated with pain endurance in addition to pain quality. The DNIC response (mechanical hypoalgesia) was independent of the 3 latent pain responses, consistent with previous findings.<sup>17</sup> These collective findings further support the multidimensional nature of pain.

The emergence of this 3-factor pain structure suggests that unidimensional assessments of pain (eg, intensity only) are incomplete. However, assessing intensity using multiple instruments may not be particularly informative, as indicated by the high correlations between the pain-intensity assessments (eVAS, VAS, and the Borg NRS). Future studies investigating the role of individual differences on pain response may benefit from intensity, quality, and tolerance pain assessments, when possible.

Only 1 of the 3 pain factors, Qualitative Pain, was significantly predicted by the latent psychological variables. Although the latent Negative Affect Factor did not add significantly to the model, neuroticism and negative affect contributed to the latent Pain- or Body Sensitivity Factor. Thus, a portion of this higher-order negative trait appears to be related to pain quality. The mechanisms linking qualitative pain to the latent pain-related factor are unclear. It may be due to cortical processing in higher brain centers associated with affective dimensions of pain and mood, such as the anterior cingulate cortex<sup>67</sup> or thalamus,<sup>69</sup> or simply be a result of the similarity between self-report questionnaires and qualitative pain assessments compared to intensity or tolerance measures.

Pain quality has not been routinely assessed in prior studies in healthy populations, whereas the relation between intensity or tolerance and psychological factors has been frequently examined. Unlike our findings, others have observed associations between fear of pain and CPT intensity when assessed at pain threshold and tolerance,<sup>26</sup> and when dichotomized between individuals with high and low fear scores.<sup>57</sup> It is not clear whether these discrepancies may be due to methodological differences: comparing a subset of the study cohort (eg, high vs low scorers); pain ratings at threshold and

**Table 7. Regression Models to Predict the 3 Latent Pain Response Factors by the 3 Latent Psychological Factors, Controlling for Sex**

<i>MODEL 1 – PREDICTING PAIN INTENSITY FACTOR</i>				
<i>SUMMARY STATISTICS</i>	<i>PREDICTOR VARIABLES</i>	<i>STANDARDIZED <math>\beta</math></i>	<i>T</i>	<i>P VALUE</i>
$R^2 = .08$	Pain-or Body Sensitivity Factor	.21	1.66	.10
Adj $R^2 = .02$	Positive Affect Factor	-.16	-1.27	.21
$F = 1.37$	Negative Affect Factor	-.15	-1.20	.23
$P = .26$	Sex	.004	.03	.97
<i>MODEL 2 – PREDICTING PAIN TOLERANCE FACTOR</i>				
<i>SUMMARY STATISTICS</i>	<i>PREDICTOR VARIABLES</i>	<i>STANDARDIZED <math>\beta</math></i>	<i>T</i>	<i>P VALUE</i>
$R^2 = .15$	Pain-or Body Sensitivity Factor	-.09	-.73	.47
Adj $R^2 = .10$	Positive Affect Factor	-.14	-1.15	.25
$F = 2.78$	Negative Affect Factor	.13	1.12	.27
$P = .03^*$	Sex	-.33	-2.75	.008†
<i>MODEL 3 – PREDICTING QUALITATIVE PAIN FACTOR</i>				
<i>SUMMARY STATISTICS</i>	<i>PREDICTOR VARIABLES</i>	<i>STANDARDIZED <math>\beta</math></i>	<i>T</i>	<i>P VALUE</i>
$R^2 = .28$	Pain-or Body Sensitivity Factor	.43	3.93	.0002†
Adj $R^2 = .23$	Positive Affect Factor	-.002	-.02	.99
$F = 5.85$	Negative Affect Factor	-.02	-.19	.85
$P < .0001†$	Sex	-.28	-2.54	.014*

NOTE. Dummy variable for sex defined as male = 0, female = 1.

\* $P \leq .05$ .

† $P \leq .01$ .

tolerance rather than peak pain anytime during the protocol; or other possible methodological differences such as instructional set. Despite the relatively weak associations observed in our study between fear of pain and pain intensity, fear may play a larger role in clinical pain. That is, the CPT may not induce high levels of fear despite the relatively high levels of pain.

Although initially included as a fear-related measure, anxiety sensitivity has also been described as a “tendency to catastrophize anxiety-related somatic sensations.”<sup>12</sup> Indeed, we observed that anxiety sensitivity was more closely associated with pre-pain catastrophizing and hypochondriasis (Whiteley Index) than pain-related fear. Although anxiety sensitivity is not frequently investigated, anxiety sensitivity has been reported to relate to CPT pain intensity<sup>57</sup> and was predictive of weekly headache.<sup>12</sup> Our results suggest anxiety sensitivity may be relevant for future investigations of individual differences in pain perception.

The Whiteley Index and somatosensory amplification were initially included as related measures of hypochondriasis. However, somatosensory amplification correlated approximately equally across the lower-order pain-related constructs, and the Whiteley Index correlated most strongly with pain catastrophizing and anxiety sensitivity. In agreement with our study, associations between pain and the Whiteley Index<sup>59</sup> and somatosensory amplification<sup>20,30,31,37,38,55</sup> have been observed in clinical populations. However, our result is

noteworthy, in that it contradicts the suggestion that somatosensory amplification is related to pain conditions involving the head or trunk but not the extremities.<sup>30,31</sup> Thus, somatosensory amplification and the Whiteley Index appear to be tapping into the same underlying latent factor as the fear and catastrophizing constructs, and accordingly may be relevant to future biopsychosocial pain models.

Pre- and post-task pain catastrophizing, although correlated, differed in their structure within the latent psychological variables. The pre-task catastrophizing ratings were more strongly associated with the higher-order negative valence traits than the post-task pain catastrophizing ratings; and pre-task pain catastrophizing loaded more highly than post-task catastrophizing on the latent Pain- and Body Sensitivity factor. These findings support the theory proposed by Turner and Aaron<sup>66</sup> that pre-pain catastrophizing assessments have traitlike, dispositional properties, whereas post-pain assessments provide situation-specific, statelike information. Our findings are consistent with previous studies demonstrating stronger correlations between pain intensity and post-pain catastrophizing than pre-pain catastrophizing.<sup>11,16,63</sup> Situational catastrophizing measures (eg, during pain) may be more relevant to acute pain perception than dispositional measures,<sup>15,16</sup> and may be a result of latent vulnerabilities that are exacerbated by painful experiences.<sup>52</sup> However, its predictive value is less apparent as the pain experience precedes the situational cognitions.

Pain inhibition, as measured by the observed DNIC response, was not associated with either CPT pain ratings or the psychological measures. While little is known about the psychological and physiological correlates of inhibitory processes in healthy individuals, this finding is consistent with the finding that DNIC responses were not related to heat pain threshold, tolerance, temporal summation, or scores on mood or stress reactivity.<sup>17</sup> Thus, personality may influence facilitatory pain pathways and/or processing to a greater extent than inhibitory pain pathways.

There are several limitations to the current study. First, this sample was young and healthy and thus may not fully generalize to clinical or older samples. Second, the sample size was relatively small (N = 66). Third, the CPT represents only 1 model of acute experimental pain. Pain responses can vary across various pain modalities;<sup>34</sup> it is unknown how the results of the current study will generalize to chronic pain and/or other models of experimental pain (eg, muscle or visceral). Fourth, almost all of the measures were subjective and self-report; consequently, associations may be partially a result of similar response biases. Despite these limitations, this study represents a unique approach to investigating the hierarchical relation of personality and psychological constructs to acute pain perception in healthy adults with a commonly used experimental pain model.

Several conclusions can be drawn from these findings: 1) numerous lower-order, pain-related constructs, along

with neuroticism and negative affect, load on a single latent factor, which we refer to as the Pain- or Body Sensitivity Factor; 2) CPT pain quality is more strongly correlated with this single latent factor than the independent higher-order personality factors; 3) the higher-order, negative valence traits (negative affect/neuroticism) are related to the Pain- or Body Sensitivity Factor, but not the positive traits (extraversion/positive affect) or psychoticism; and 3) the relations between psychological factors and pain can depend on the form of pain assessment (ie, quality, tolerance, or intensity). Further, these results suggest somatosensory amplification, hypochondriasis, and anxiety sensitivity may be salient factors to include in future studies investigating individual differences in pain perception, in addition to the more commonly studied catastrophizing and fear constructs.

These findings could have important practical implications, as certain factors assessed a priori (eg, preoperatively) may have predictive value for who will perceive greater pain using qualitative assessments. A better understanding of the structure defined by potential pain-related psychological variables and their influence on the perception of acute pain may assist in the development of future treatment. Individualized multidisciplinary therapeutic interventions may be plausible to better meet the needs of patients for a variety of acute pain conditions. Further investigation using additional experimental and clinical pain cohorts are warranted to clarify the nature of these observed relationships.

## References

- Affleck G, Tennen H, Urrows S, Higgins P: Neuroticism and the pain-mood relation in rheumatoid arthritis: Insights from a prospective daily study. *J Consult Clin Psychol* 60: 119-126, 1992
- Asmundson GJG, Wright KD, Hadjistavropoulos HD: Hypervigilance and attentional fixedness in chronic musculoskeletal pain: Consistency of findings across modified strop and dot-probe tasks. *J Pain* 6:497-506, 2005
- Barnes LLB, Harp D, Jung WS: Reliability generalization of scores on the Spielberger State-Trait Anxiety Inventory. *Educ Psychol Meas* 62:603-618, 2002
- Barsky AJ, Wyshak G, Klerman GL: The somatosensory amplification scale and its relationship to hypochondriasis. *J Psychiatr Res* 24:323-334, 1990
- Capodaglio EM: Comparison between the CR10 Borg's Scale and the VAS (Visual Analogue Scale) during an arm-cracking exercise. *J Occup Rehabil* 11, 2001
- Cattell RB: The scree test for the number of factors. *Multivariate Behav Res* 1:245-276, 1966
- Chesterton LS, Barlas P, Foster NE, Baxter GD, Wright CC: Gender differences in pressure pain threshold in healthy humans. *Pain* 101:259-266, 2003
- Cook DB, O'Connor PJ, Eubanks SA, Smith JC, Lee M: Naturally occurring muscle pain during exercise: Assessment and experimental evidence. *Med Sci Sports Exerc* 29: 999-1012, 1997
- Crombez G, Vlaeyen JW, Heuts PH, Lysens R: Pain-related fear is more disabling than pain itself: Evidence on the role of pain-related fear in chronic back pain disability. *Pain* 80: 329-339, 1999
- David JP, Green PJ, Martin R, Suls J: Differential roles of neuroticism, extraversion, and event desirability for mood in daily life: An integrative model of top-down and bottom-up influences. *J Pers Soc Psychol* 73:149-159, 1997
- Dixon KE, Thorn BE, Ward LC: An evaluation of sex differences in psychological and physiological responses to experimentally-induced pain: A path analytic description. *Pain* 112:188-196, 2004
- Drahovzal DN, Stewart SH, Sullivan MJ: Tendency to catastrophize somatic sensations: Pain catastrophizing and anxiety sensitivity in predicting headache. *Cogn Behav Ther* 35:226-235, 2006
- Draycott SG, Kline P: The Big Three or the Big Five—the EPQ-R vs the NEO-PI: A research note, replication and elaboration. *Pers Indiv Diff* 18:801-804, 1995
- Dudgeon D, Raubertas RF, Rosenthal SN: The short-form McGill Pain Questionnaire in chronic cancer pain. *J Pain Symptom Manage* 8:191-195, 1993
- Edwards RR: Age differences in the correlates of physical functioning in patients with chronic pain. *J Aging Health* 18: 56-69, 2006
- Edwards RR, Campbell CM, Fillingim RB: Catastrophizing and experimental pain sensitivity: Only in vivo reports of catastrophic cognitions correlate with pain responses. *J Pain* 6:338-339, 2005

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17. Edwards RR, Ness TJ, Weigent DA, Fillingim RB: Individual differences in diffuse noxious inhibitory controls (DNIC): Association with clinical variables. *Pain* 106: 427-437, 2003

18. Eysenck HJ, Eysenck SBG: *Manual of the Eysenck Personality Questionnaire: Comprising the EPQ-Revised (EPQ-R) and EPQ-R Short Scale*. San Diego, CA, EdITS, 1994

19. Ferracuti S, De Carolis A: Relationships among Eysenck's extraversion, Rorschach's Erlebnistypus, and tolerance of experimental tonic pain (Cold Water Pressor Test). *Percept Mot Skills* 100:237-248, 2005

20. Feuerstein M, Beattie P: Biobehavioral factors affecting pain and disability in low back pain: Mechanisms and assessment. *Phys Ther* 75:267-280, 1995

21. Fillingim RB: Individual differences in pain responses. *Curr Rheumatol Rep* 7:342-347, 2005

22. Fischer AA: Reliability of the pressure algometer as a measure of myofascial trigger point sensitivity. *Pain* 28: 411-414, 1987

23. Fishbain DA, Cole B, Cutler RB, Lewis J, Rosomoff HL, Rosomoff RS: Chronic pain and the measurement of personality: Do states influence traits? *Pain Med* 7:509-529, 2006

24. Garofalo JP, Lawler C, Robinson R, Morgan M, Kenworthy-Heinige T: The role of mood states underlying sex differences in the perception and tolerance of pain. *Pain Pract* 6: 186-196, 2006

25. Gatchel RJ, Kishino N: Influence of personality characteristics of pain patients: Implications for causality in pain, in Young G, Kane A, Nicholson K (eds): *Psychological Knowledge in Court* (1st ed.). Cambridge, MA, Springer, 2006, pp 149-162

26. George SZ, Dannecker EA, Robinson ME: Fear of pain, not pain catastrophizing, predicts acute pain intensity, but neither factor predicts tolerance or blood pressure reactivity: An experimental investigation in pain-free individuals. *Eur J Pain* 10:457-465, 2006

27. George SZ, Wittmer VT, Fillingim RB, Robinson ME: Sex and pain-related psychological variables are associated with thermal pain sensitivity for patients with chronic low back pain. *J Pain* 8:2-10, 2007

28. Goubert L, Crombez G, Van Damme S: The role of neuroticism, pain catastrophizing and pain-related fear in vigilance to pain: A structural equations approach. *Pain* 107: 234-241, 2004

29. Granot M: Personality traits associated with perception of noxious stimuli in women with vulvar vestibulitis syndrome. *J Pain* 6:168-173, 2005

30. Gregory RJ, Manring J, Berry SL: Pain location and psychological characteristics of patients with chronic pain. *Psychosomatics* 41:216-220, 2000

31. Gregory RJ, Manring J, Wade MJ: Personality traits related to chronic pain location. *Ann Clin Psychiatry* 17: 59-64, 2005

32. Harms-Ringdahl K, Carlsson AM, Ekholm J, Raustorp A, Svensson T, Toresson HG: Pain assessment with different intensity scales in response to loading of joint structures. *Pain* 27:401-411, 1986

33. Hasson D, Arnetz BB: Validation and findings comparing VAS vs. Likert scales for psychosocial measurements. In: *The*

**Pain-Related Constructs Predict Cold-Pressor Pain**

*International Electronic Journal of Health Education* 8: 178-192, 2005

34. Hastie BA, Riley JL 3rd, Robinson ME, Glover T, Campbell CM, Staud R, Fillingim RB: Cluster analysis of multiple experimental pain modalities. *Pain* 116:227-237, 2005

35. James JE, Hardardottir I: Influence of attention focus and trait anxiety on tolerance of acute pain. *Br J Health Psychol* 7:149-162, 2002

36. Jamison RN, Gracely RH, Raymond SA, Levine JG, Marino B, Herrmann TJ, Daly M, Fram D, Katz NP: Comparative study of electronic vs. paper VAS ratings: A randomized, crossover trial using healthy volunteers. *Pain* 99:341-347, 2002

37. Jones MP, Ebert CC: Bloating and somatosensory amplification in functional dyspepsia. *Am J Gastroenterol* 98: 5263, 2003

38. Jones MP, Roth LM, Crowell MD: Symptom reporting by functional dyspeptics during the water load test. *Am J Gastroenterol* 100:1334-1339, 2005

39. Keogh E, Hamid R, Hamid S, Ellery D: Investigating the effect of anxiety sensitivity, gender and negative interpretative bias on the perception of chest pain. *Pain* 111:209-217, 2004

40. Keogh E, Mansoor L: Investigating the effects of anxiety sensitivity and coping on the perception of cold pressor pain in healthy women. *Eur J Pain* 5:11-22, 2001

41. Markón KE, Krueger RF, Watson D: Delineating the structure of normal and abnormal personality: An integrative hierarchical approach. *J Pers Soc Psychol* 88:139-157, 2005

42. McCracken LM, Gross RT, Aikens J, Carnrike CL Jr.: The assessment of anxiety and fear in persons with chronic pain: A comparison of instruments. *Behav Res Ther* 34: 927-933, 1996

43. McNeil DW, Au AR, Zvolensky MJ, McKee DR, Klineberg IJ, Ho CC: Fear of pain in orofacial pain patients. *Pain* 89:245-252, 2001

44. McNeil DW, Rainwater AJ 3rd: Development of the Fear of Pain Questionnaire-III. *J Behav Med* 21:389-410, 1998

45. Melzack R: The short-form McGill Pain Questionnaire. *Pain* 30:191-197, 1987

46. Mitchell LA, MacDonald RA, Brodie EE: Temperature and the cold pressor test. *J Pain* 5:233-237, 2004

47. Mongini F, Ciccone G, Deregibus A, Ferrero L, Mongini T: Muscle tenderness in different headache types and its relation to anxiety and depression. *Pain* 112:59-64, 2004

48. Nicholas MK: Chronic pain, in Wilson PH (ed): *Principles of Practice and Relapse Prevention* (1st ed.). New York, NY, Guilford Press, 1992, pp 255-289

49. Osman A, Breitenstein JL, Barrios FX, Gutierrez PM, Kopper BA: The Fear of Pain Questionnaire-III: Further reliability and validity with nonclinical samples. *J Behav Med* 25:155-173, 2002

50. Pallegama RW, Ranasinghe AW, Weerasinghe VS, Sitheequ MA: Anxiety and personality traits in patients with muscle related temporomandibular disorders. *J Oral Rehabil* 32:701-707, 2005

51. Pilowsky I: Dimensions of hypochondriasis. *Br J Psychiatry* 113:89-93, 1967

52. Pincus T, Morley S: Cognitive-processing bias in chronic pain: A review and integration. *Psychol Bull* 127:599-617, 2001
53. Price DD, McGrath PA, Rafii A, Buckingham B: The validation of visual analogue scales as ratio scale measures for chronic and experimental pain. *Pain* 17:45-56, 1983
54. Ramirez-Maestre C, Lopez Martinez AE, Zarazaga RE: Personality characteristics as differential variables of the pain experience. *J Behav Med* 27:147-165, 2004
55. Raphael KG, Marbach JJ, Gallagher RM: Somatosensory amplification and affective inhibition are elevated in myofascial face pain. *Pain Med* 1:247-253, 2000
56. Reiss S, Peterson RA, Gursky DM, McNally RJ: Anxiety sensitivity, anxiety frequency and the prediction of fearfulness. *Behav Res Ther* 24:1-8, 1986
57. Roelofs J, Peters ML, van der Zijden M, Vlaeyen JW: Does fear of pain moderate the effects of sensory focusing and distraction on cold pressor pain in pain-free individuals? *J Pain* 5:250-256, 2004
58. Rolke R, Andrews Campbell K, Magerl W, Treede RD: Deep pain thresholds in the distal limbs of healthy human subjects. *Eur J Pain* 9:39-48, 2005
59. Ryall C, Coggon D, Peveler R, Reading I, Palmer KT: A case-control study of risk factors for arm pain presenting to primary care services. *Occup Med (Lond)* 56:137-143, 2006
60. Snyder CR, Berg C, Woodward JT, Gum A, Rand KL, Wroblewski KK, Brown J, Hackman A: Hope against the cold: Individual differences in trait hope and acute pain tolerance on the cold pressor task. *J Pers* 73:287-312, 2005
61. Spielberger CD: *Manual for the State-Trait Anxiety Inventory (STAI)* (1st ed.). Palo Alto, CA, Consulting Psychologists Press, 1983
62. Sullivan MJL, Bishop SR, Pivik J: The Pain Catastrophizing Scale: Development and validation. *Psychol Assess* 7: 524-532, 1995
63. Thorn BE, Clements KL, Ward LC, Dixon KE, Kersh BC, Boothby JL, Chaplin WF: Personality factors in the explanation of sex differences in pain catastrophizing and response to experimental pain. *Clin J Pain* 20:275-282, 2004
64. Timmermans G, Sternbach RA: Factors of human chronic pain: An analysis of personality and pain reaction variables. *Science* 184:806-808, 1974
65. Turk DC, Monarch ES: Biopsychosocial perspective on chronic pain, in Turk DC, Gatchel RJ (eds): *Psychological Approaches to Pain Management: A Practitioner's Handbook* (2nd ed.). New York, NY, Guilford Press, 2002, pp 3-29
66. Turner JA, Aaron LA: Pain-related catastrophizing: What is it? *Clin J Pain* 17:65-71, 2001
67. Villemure C, Bushnell MC: Mood influences supraspinal pain processing separately from attention. *J Neurosci* 29: 705-715, 2009
68. Vujanovic AA, Arrindell WA, Bernstein A, Norton PJ, Zvolensky MJ: Sixteen-item Anxiety Sensitivity Index: Confirmatory factor analytic evidence, internal consistency, and construct validity in a young adult sample from the Netherlands. *Assessment* 14:129-143, 2007
69. Wagner G, Koschke M, Leuf T, Schlosser R, Bar KJ: Reduced heat pain thresholds after sad-mood induction are associated with changes in thalamic activity. *Neuropsychologia* 47:980-987, 2009
70. Watson D, Clark LA: Negative affectivity: The disposition to experience aversive emotional states. *Psychol Bull* 96: 465-490, 1984
71. Watson D, Clark LA: Affects separable and inseparable: On the hierarchical arrangement of the negative affects. *J Pers Soc Psychol* 62:489-505, 1992
72. Watson D, Clark LA, Harkness AR: Structures of personality and their relevance to psychopathology. *J Abnorm Psychol* 103:18-31, 1994
73. Watson D, Clark LA, Tellegen A: Development and validation of brief measures of positive and negative affect: The PANAS scales. *J Pers Soc Psychol* 54:1063-1070, 1988
74. Wolf S, Hardy JD: Studies on pain: Observations on pain due to local cooling and on factors involved in the "cold pressor" effect. *J Clin Invest* 20:521-533, 1941
75. Wolff B: Factor analysis of human pain responses: pain endurance as a specific pain factor. *J Abnorm Psychol* 78: 292-298, 1971
76. Zalon ML: Comparison of pain measures in surgical patients. *J Nurs Meas* 7:135-152, 1999
77. Zuckerman M, Kuhlman DM, Joireman J, Teta P, Kraft M: A comparison of three structural models for personality: The Big Three, the Big Five, and the Alternative Five. *J Pers Soc Psychol* 65:757-768, 1993