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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 three latent psychological variables: pain- or body-sensitivity, negative affect/neuroticism, and positive affect/extraversion. Similarly, pain responses factored into three domains: intensity, quality, and tolerance. Regression and correlation analyses demonstrated 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.

Keywords

experimental pain; neuroticism; pain catastrophizing; fear of pain; anxiety sensitivity; somatosensory amplification

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Introduction

Pain is a significant health concern with considerable economic and emotional costs. In the United States, pain accounts for 80% of all physician visits²⁵ and 10% of Americans experience pain 100 days or longer annually⁴⁹. However, pain perception can vary greatly between individuals²¹. According to the biopsychosocial model, individual differences in pain sensitivity may be explained by the interaction between physiological, psychological, and social variables⁶⁶. Consistent with this theory, certain psychological factors are increasingly recognized 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^{27, 28}; fear of pain^{9, 44}; anxiety^{43, 48, 51}; anxiety sensitivity^{2, 39}; and somatosensory amplification^{31, 56}. Neuroticism/negative affectivity, a broad, higher-order trait associated with negative emotions, cognitions, and self-concept^{18, 71}, also is correlated with symptom severity in some chronically painful conditions^{1, 29}.

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 (i.e., improve) following successful chronic pain treatment²³. While informative, clinical samples rarely are able to assess baseline psychological variables in the absence of pain. Experimental pain studies involving healthy individuals, although lacking in regards to dimensions of the chronic pain experience (e.g., duration, pathology, co-morbidities), 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^{11, 26, 64}. Numerous associations between CPT pain and a variety of lower-order psychological constructs have been reported, including: negative mood²⁴, pain catastrophizing^{11, 64}, fear of pain^{26, 58}, anxiety^{19, 35}, anxiety sensitivity^{40, 58}, and emotional vulnerability^{11, 64}. Relatively few studies have assessed traditional higher-order personality traits, with mixed results. Negative or positive affect did not relate to pain intensity⁶³ or tolerance⁶¹, whereas extraversion correlated with pain tolerance in two studies^{19, 55}. To our knowledge, several potential higher- and lower-order traits (e.g., neuroticism, psychoticism, somatosensory amplification, 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 (e.g., extraversion, positive emotionality, surgency) and structures ranging from two- to sixteen-factor models. However, personality structure is now generally conceived as a hierarchical model, with broad higher-order factors (e.g., neuroticism, extraversion) at the top, and narrower, more specific lower-order factors facets or dimensions (e.g., fear, hostility) below^{13, 42, 78}. It is unknown whether lower-order, pain-related constructs are simply facets of higher-order traits (e.g., neuroticism or negative affect) or distinct dimensions of personality. Certainly, the associations between pain and isolated lower-level constructs may be 1) attributable to neuroticism, or 2) due to another underlying latent construct^{66, 72}.

Measuring multiple levels of personality is necessary to disentangle the underlying hierarchical structure and the potential relative contributions of psychological factors to pain perception⁷². Few studies have investigated the roles and interactions of multiple higher- and lower-order traits and constructs on pain perception in one 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 (e.g., neuroticism, negative affect, trait anxiety, extraversion,

positive affect, psychoticism) and three 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).

Materials and Methods

Participants

Sixty-six healthy, pain-free volunteers were recruited from the local and University community. Thirty-three females (mean age 30.1 ± 11.5 yrs) and 33 males (mean age 29.7 ± 11.4 yrs) participated in the study; overall mean (SD) age was 29.9 (11.3), and the age range was 18-54 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 (e.g., 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.

Apparatus and Measures

Cold Pressor Task—Participants submersed their non-dominant 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^{47, 75}. The forearm was supported using a soft armrest to maintain 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” (i.e., pain threshold). They were also instructed that if the pain became intolerable, they could remove their hand at any time without penalty (i.e., 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 0-10 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 ($r = 0.78$ to 0.99)³², muscle-ache during an arm-cranking exercise ($r = 0.99$)⁵, and exercise-induced muscle pain⁸.

Electronic Visual Analog Scale: Participants were instructed to rate their pain intensity continuously during the CPT using a 0-10 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 ratings were updated at a minimum of every 15–20 seconds. Pain ratings were recorded electronically on a laptop computer (100 Hz sampling rate) to the nearest millimeter. The VAS is the most commonly used clinical and experimental pain assessment tool due to its simplicity, efficiency⁵⁴, and ability to detect small differences in ratings³³; eVAS measures are valid and reliable for assessing pain perception³⁶.

Short-Form McGill Pain Questionnaire: The short-form McGill Pain Questionnaire (MPQ)⁴⁶ is comprised of three subscales, providing both qualitative and quantitative pain assessments. Participants rated their pain on a 15-adjective verbal descriptor pain scale with eleven items reflecting sensory and four 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 reliable⁷⁷ and valid instrument^{14, 46}.

Pressure Pain Thresholds: Pressure pain threshold (PPT) is defined as the amount of force needed to elicit a sensation of pain distinct from pressure²² and was assessed using a hand-held digital pressure algometer (Somedic AB, Farsta Sweden). The mean of two PPT repetitions were recorded for baseline (pre-CPT) and immediately following the cold pressor task (~3-4 minutes post-CPT) at four locations outside of the immersed region: the ipsilateral forearm of the test limb and three locations contralaterally: the thenar eminence and inside of the middle distal phalanx of the hand, and the forearm. The algometer was applied perpendicularly using a 1 cm² 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 four 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^{7, 59}.

Higher-Order Personality Measures—The Eysenck Personality Questionnaire-Revised (EPQ-R)¹⁸ is a 100-item self-report instrument containing four 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 non-conformist personality¹⁸. The EPQ-R scales have been demonstrated to have good internal consistency and test-retest reliability¹⁸. The Lie scale was not used in this study.

The Positive and Negative Affect Schedule (PANAS)⁷⁴ is a valid and reliable self-report measure of positive (PA) and negative affect (NA)⁷⁴. The scale consists of 20 single mood descriptors, 10 per scale. Participants rate each word (e.g., “interested”, “distressed”) in terms

of the extent to which they “generally feel this way, that is, on the average” (i.e., 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)⁶², a self-report measure of anxiety-proneness with excellent internal consistency and reliability³. 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 consistency⁴⁵. Participants rate their anticipated fear of the pain associated with each event on a 5-point Likert scale. The FPQ contains three 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)⁵⁷, a 16-item self-report instrument with good test-retest reliability^{56 40} and internal consistency⁶⁹. 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)⁶³. Thorn and colleagues suggest that pain-related catastrophizing during the cold pressor task (i.e., situational) may be more correlated with pain reports than generalized (i.e., dispositional) pain catastrophizing assessed a priori^{11, 16, 64}. 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.

Sensitivity to bodily sensations and hypochondriasis was assessed with two measures as well. The Somatosensory Amplification Scale (SSAS)⁴ is a 10-item self-report measure of sensitivity to a range of normal bodily sensations (e.g., “I hate to be too hot or too cold”) using a 5-point scale. The SSAS demonstrates good internal consistency and test-retest reliability⁴. 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 reliability⁵².

Procedures

All participants completed one session lasting approximately one hour. After providing written informed consent, participants' blood pressure was measured to ensure study criteria were met. Participants then completed eight 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 PPT's were then measured at the four locations. All participants immersed their non-dominant hand to the wrist in a bucket of warm water (~92° F) for five minutes to normalize the starting hand temperature, followed by the CPT using the non-dominant 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 PPT's 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 using Principal Axis Factoring with varimax rotation (SPSS); the number of retained factors was determined by examining the scree plot⁶ 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 $p = 0.05$, unless otherwise noted.

Results

Summary statistics for all psychological and pain variables are listed in Table 1. Seventeen participants reached the five minute uninformed maximum time (12 males, 5 females), and were asked to remove their hand (five 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 four locations, with no significant between-site differences ($F_{3, 192} = 1.33, p = 0.27$). 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 $r = 0.18$ to 0.84 (Table 2). The predominantly quantitative pain intensity measures (i.e., Borg NRS, peak eVAS, VAS) were highly correlated ($r = 0.66$ to $0.84, p < .01$) and the qualitative pain descriptor scales (i.e., MPQ total and PPI) were significantly correlated ($r = 0.52, p < .01$). However, associations between the quantitative and qualitative pain ratings were more variable, ranging from $r = 0.18$ to 0.62 .

CPT pain threshold and tolerance times were significantly positively correlated ($r = 0.45, p < 0.01$). Pain threshold was only correlated with one pain measure, the PPI ($r = -0.32, p < .05$), indicating lower thresholds were associated with higher PPI ratings. Tolerance time was significantly negatively correlated with the Borg NRS ($r = -0.33, p < .01$), VAS ($r = -0.31, p < .05$), and PPI ($r = -0.47, p < .01$), indicating high pain ratings were associated with shorter CPT immersions on three of the five possible scales. Neither threshold nor tolerance times were correlated with the MPQ total score ($r = -0.19$ to $-0.05, p > .13$) or peak eVAS score ($r = -0.11$ to $-0.14, p > .27$).

Three distinct latent pain response factors (Table 3) explained 59.1% of the total variance observed in the eight 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 ($p = 0.005$ and 0.013 , respectively), but the intensity factor did not ($p = 0.95$). The relative change in PPTs (DNIC response) did not load with any of the three latent pain response factors. Similarly, the DNIC response (%PPT) did not significantly correlate with any of the other pain responses ($r = -0.05$ to 0.15 ; $p = 0.23$ to 0.96).

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 ($r \geq 0.70$, $p < .01$). Similarly, the two 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.

The lower-order constructs (pre- and post-pain catastrophizing, fear of pain, anxiety sensitivity, somatosensory amplification, hypochondriasis) were consistently inter-correlated ($r = 0.25$ to 0.62 , $p < .05$, 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 four of the six constructs being correlated to all three 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 ($r = -0.28$ to -0.37 , $p < .05$). No significant sex differences were noted for any of the psychological measures (Table 1).

Three latent factors were extracted from the twelve personality and pain-related construct variables, explaining a total of 51.5% of the response variance (Table 5). Only one 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 three highest loadings on the latent Pain- or Body 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 two and three. Psychoticism did not load highly on any of the three latent psychological factors. No sex differences were observed for any of the three latent psychological variables ($p = 0.56$ to 0.64).

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 three 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 ($p = 0.03$), but only sex was a significant predictor ($p = 0.008$). The third latent pain factor (Qualitative) was also significantly predicted by the model ($p < 0.0001$); Pain- or Body Sensitivity was the strongest predictor even when controlling for sex ($p < 0.001$).

Discussion

This study demonstrates that lower-order, pain-related constructs are inter-related, 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 three 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 1) multiple pain-related constructs are related to qualitative pain by 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 sub-facets, including: fear, hostility, guilt, anger, anxiety, and stress reactivity⁷³. Research demonstrates various measures of negative affect and neuroticism are tapping into a common factor structure^{71 72}, with moderate to strong associations being observed between neuroticism and measures of negative mood^{1, 10} and trait anxiety⁷¹.

Although each lower-order, pain-related construct was chosen as a measure of a specific domain (e.g., fear/anxiety, somatosensory amplification, or catastrophizing), they were moderately to strongly inter-correlated 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^{26, 50, 63}. The observation of one 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 three 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 unpleasantness⁵⁴. Whereas qualitative indices assess the unpleasant nature of pain, quantitative measures assess the sensory-discriminative component of pain⁴⁶. The latent pain factor we termed 'Qualitative' may be similar to Price's affective dimension 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^{65, 76}. PPI loaded primarily on the qualitative factor, but loaded secondarily on the Tolerance factor. This may suggest the descriptor options for the PPI (e.g., "distressing" or "excruciating") tap into cognitions associated with pain endurance in addition to pain quality. The DNIC response (mechanical hypoalgesia) was independent of the three latent pain responses, consistent with previous findings¹⁷. These collective findings further support the multidimensional nature of pain.

The emergence of this three factor pain structure suggests that unidimensional assessments of pain (e.g., 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 one of the three 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 cortex⁶⁸ or thalamus⁷⁰; 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 tolerance²⁶, and when dichotomized between individuals with high and low fear scores⁵⁸. It is not clear whether these discrepancies may be due to methodological differences: comparing a subset of the study cohort (e.g., high versus low scorers), pain ratings at threshold and 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”¹². Indeed, we observed 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 intensity⁵⁸ and was predictive of weekly headache¹². 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 Index⁶⁰ and somatosensory amplification^{20, 30, 31, 37, 38, 56} 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^{30, 31}. 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 Aaron⁶⁷ that pre-pain catastrophizing assessments have trait-like, dispositional properties, whereas post-pain assessments provide situation-specific, state-like information. Our findings are consistent with previous studies demonstrating stronger correlations between pain intensity and post- pain catastrophizing than pre-pain catastrophizing^{11, 16, 64}. Situational catastrophizing measures (e.g., during pain) may be more relevant to acute pain perception than dispositional measures^{15, 16}, and may be a result of “latent vulnerabilities” that are exacerbated by painful experiences⁵³. 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 reactivity¹⁷. 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; thus, may not fully generalize to clinical or older samples. Second, the sample size was relatively small (N = 66). Third, the CPT represents only one model of acute experimental pain. Pain responses can vary across various pain modalities³⁴; it is unknown how the results of the current study will generalize to chronic pain and/or other models of experimental pain (e.g., 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 (i.e., 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 (e.g., 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.

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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)	0.87
Height (cm) *	167.1 (6.9)	180.0 (5.6)	173.1 (8.6)	<0.001
Weight (kg) *	68.19 (12.2)	77.8 (10.6)	73.1 (12.3)	0.001
Neuroticism (0-24)	9.5 (4.4)	8.0 (5.0)	8.8 (4.7)	0.22
Negative Affect (10-50)	15.0 (3.0)	15.8 (4.8)	15.4 (4.0)	0.43
Trait Anxiety (20-80)	33.3 (8.3)	32.8 (8.9)	33.0 (8.5)	0.84
Pre-Pain Catastrophizing (0-52)	10.9 (7.6)	14.1 (8.7)	12.5 (8.3)	0.12
Post-Pain Catastrophizing (0-52)	15.0 (9.8)	16.0 (13.1)	15.5 (11.5)	0.72
Fear of Pain (30-150)	75.6 (16.6)	73.7 (17.9)	74.6 (17.1)	0.66
Anxiety Sensitivity (0-64)	14.7 (7.1)	14.8 (7.9)	14.7 (7.4)	0.96
Somatosensory Amplification (10-50)	25.4 (5.4)	24.4 (5.6)	24.9 (5.5)	0.45
Whiteley Index (14-70)	19.9 (5.6)	20.8 (5.6)	20.4 (5.6)	0.52
Psychoticism (0-33)	5.7 (3.18)	6.6 (3.29)	6.1 (3.24)	0.29
Extraversion (0-22)	15.0 (5.41)	14.3 (5.61)	14.7 (5.48)	0.63
Positive Affect (10-50)	35.8 (5.85)	36.1 (5.48)	36.0 (5.62)	0.81
CPT Pain Threshold (sec)	15.8 (14.06)	15.9 (10.67)	15.9 (12.4)	0.98
CPT Tolerance (sec) (0-300) *	101.9 (96.8)	181.0 (112.7)	141.4 (111.6)	0.003
Borg NRS (0-10)	6.9 (1.9)	7.0 (1.8)	7.0 (1.8)	0.87
Peak eVAS (cm) (0-10)	7.5 (2.2)	7.4 (2.2)	7.5 (2.3)	0.56
VAS (cm) (0-10)	7.3 (1.8)	7.3 (1.9)	7.3 (1.8)	0.94
MPQ Total (0-45)	10.6 (6.3)	13.5 (7.0)	12.1 (6.8)	0.08
PPI (0-5)	3.0 (0.8)	3.1 (0.9)	3.1 (0.8)	0.66
PPT (%)	111.4 (16.6)	109.1 (17.5)	110.2 (17.0)	0.59

* Significant difference between females and males with Bonferroni correction, $p \leq 0.002$.

Note: 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.

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

[†] $p \leq .01$;

* $p \leq .05$

Note: 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.

Table 3

Pain variable factor loadings using Principal Axis Factoring with Varimax rotation.

	Factor 1	Factor 2	Factor 3
Name	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

Factor loadings > 0.40 are shown in bold.

Note: 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.

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 [†]

[†] p ≤ .01;

* p ≤ .05

Note: 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.

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

Factor loadings > 0.40 are shown in bold.

* Indicates factor loading coefficients are reversed keyed.

Note: 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.

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

[†] $p \leq .01$.

Table 7

Regression models to predict the 3 latent pain response factors by the 3 latent psychological factors, controlling for sex.

Model 1 – Predicting Pain Intensity Factor				
Summary statistics	Predictor variables	Standardized β	t	P-value
$R^2 = 0.08$	Pain-or Body Sensitivity Factor	.21	1.66	.10
Adj $R^2 = 0.02$	Positive Affect Factor	-.16	-1.27	.21
F = 1.37	Negative Affect Factor	-.15	-1.20	.23
p = 0.26	Sex	.004	0.03	.97
Model 2 – Predicting Pain Tolerance factor				
Summary statistics	Predictor variables	Standardized β	t	P-value
$R^2 = 0.15$	Pain-or Body Sensitivity Factor	-.09	-.73	.47
Adj $R^2 = 0.10$	Positive Affect Factor	-.14	-1.15	.25
F = 2.78	Negative Affect Factor	.13	1.12	.27
p = 0.03*	Sex	-.33	-2.75	.008[†]
Model 3 – Predicting Qualitative Pain Factor				
Summary statistics	Predictor variables	Standardized β	t	P-value
$R^2 = 0.28$	Pain-or Body Sensitivity Factor	.43	3.93	.0002[†]
Adj $R^2 = 0.23$	Positive Affect Factor	-.002	-.02	.99
F = 5.85	Negative Affect Factor	-.02	-.19	.85
p < 0.0001[†]	Sex	-.28	-2.54	.014*

[†] p ≤ .01;

* p ≤ .05

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