

Pain Catastrophizing: An Updated Review

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ABSTRACT

Pain catastrophizing has been described for more than half a century which adversely affects the pain coping behavior and overall prognosis in susceptible individuals when challenged by painful conditions. It is a distinct phenomenon which is characterized by feelings of helplessness, active rumination and excessive magnification of cognitions and feelings toward the painful situation. Susceptible subjects may have certain demographic or psychological predisposition. Various models of pain catastrophizing have been proposed which include attention-bias, schema-activation, communal-coping and appraisal models. Nevertheless, consensus is still lacking as to the true nature and mechanisms for pain catastrophizing. Recent advances in population genomics and noninvasive neuroimaging have helped elucidate the known determinants and neurophysiological correlates behind this potentially disabling behavior.

Key words: Disability, pain catastrophizing, rehabilitation, review

PAIN CATASTROPHIZING: HISTORY AND DEFINITION

Catastrophizing was first coined by American psychologist Ellis^[1] in 1962 and later refined by Beck^[2] in 1987 to describe a maladaptive cognitive style originally seen in patients with anxiety and depressive disorders with an irrational negative forecast of future events. Pain is a common negative experience which signifies injury, illness, danger and possible doom. Taken together, pain catastrophizing refers to a set of exaggerated and ruminating negative cognitions and emotions during actual or perceived painful stimulation. One may argue that the earliest record of pain catastrophizing can be found in the

classic treatise of Traditional Chinese Medicine, “Ji Gui Yao Lue” (the Essays of the Golden Chamber),^[3] written in 200 A.D., which described in details a clinical condition called Zhong Zao, where the patient (often a female) exhibits feelings of worry, repetitive thoughts, helplessness and exaggerated response to pain or stress. In 1889, French writer Guy Maupassant expounded in his work “Sur L'eau” his migrainous attacks as “atrocious torment”, “worst in the world”, “driving one mad”, “scattering one's thoughts”.^[4] In 1940's, female Mexican painter Frida Kahlo^[5] portrayed her unbearable neuropathic pain and fibromyalgia due to motor vehicle accident with a series of surrealist paintings centered around the theme of brokenness and hopelessness, vividly depicted in “The broken column” and “Without hope” [Figures 1 and 2]. The earliest work on pain catastrophizing was performed by Spanos *et al.*^[6] in 1979 where individuals reported on their pain experience after a cold pressor task and those with worry, fear and inability to divert attention from pain were classified as pain catastrophisers. Chaves *et al.*^[7] in 1987 studied the thoughts and images of patients which they recalled from a stressful dental procedure and those who tend to exaggerate or magnify the

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Figure 1: Surrealistic painting titled “Without Hope” where Frida tried to externalize her chronic pain and hopelessness by portraying her bedbound self force-fed with a funnelled mixture of carcasses. Frida Kahlo, “Sin esperanza”, 1945. Oil on Canvas mounted on Masonite, 11”x14”. Collection Museo Dolores Olmedo Patino, Mexico City

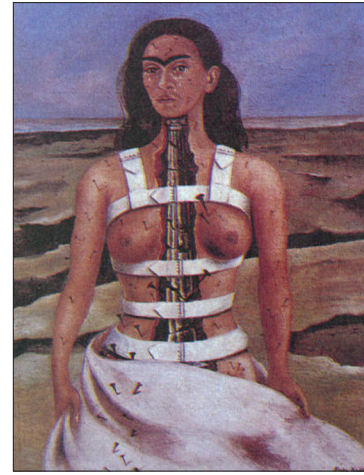


Figure 2: Frida Kahlo’s painting “broken column” where she depicted her spine as a broken marble column in the background of multiple nails driven into other parts of her naked body, giving her the continual undignifying pain. She told others “I am disintegration” Frida Kahlo, “La columna rota”, 1944. Oil on canvas mounted on rigid fiber, 16”x12”, Collection Museo Dolores Olmedo Patino, Mexico City

threat value or gravity of the situation were described as catastrophisers. Although the studies by Spanos and Chaves were limited in validity by their use of nonstandardized interview methods, it is worth noting that they formed the blueprints of situational (state) and dispositional (trait) assessments respectively. Rosentiel and Keefe^[8] were credited for defining the third domain of pain catastrophizing—helplessness and pessimism about the ability to cope—as they included a six-item subscale in debuting their Coping Strategy Questionnaire (CSQ) in 1983. This led to the subsequent development of the Pain Catastrophizing Scale (PCS) in 1995 by Sullivan *et al.*^[9] which contains thirteen items which are grouped under the three subscales [Table 1]. All items are rated in a 5-point scale, its internal consistency and validity has been demonstrated^[10] and has been found to have a high test–retest correlation ($r=0.75$) across a 6-week period for the same individual. PCS has now been translated to other languages like Chinese,^[11] Japanese,^[12,13] French,^[14] German,^[15] Dutch,^[16] Spanish,^[17] Greek^[18] and Catalan^[19] and also modified for use in children (PCS-C),^[20] adolescents (PCS-Ado)^[14] and significant other (PCS-S).^[21] Apart from becoming become the reference standard psychometric tool for pain catastrophizing, PCS also defines its three characteristic domains of helplessness, rumination and magnification. Nevertheless, there has been doubt as to the whether PCS can cover the worse-case scenario construct for pain-catastrophizing and suggestion was raised to add in items like “I might end up paralyzed”, “I might become totally disabled”, “I might end up losing my job and not able to support my family”, etc. to increase enhance the validity of PCS scale.^[22]

Table 1: Pain catastrophizing scale

Helplessness subscale	
It is terrible and I think it is never going to get any better	
It is awful and I feel that it overwhelms me	
I worry all the time about whether the pain will end	
I feel I can not stand it anymore	
I feel I can not go on	
There is nothing I can do to reduce the intensity of the pain	
Rumination subscale	
I anxiously want the pain to go away	
I can not seem to keep it out of my mind	
I keep thinking about how much it hurts	
I keep thinking about how badly I want the pain to stop	
Magnification subscale	
I become afraid that the pain will get worse	
I keep thinking of other painful events	
I wonder whether something serious may happen	

PAIN CATASTROPHIZING AND PHYSICAL DISABILITY

Clinically, pain catastrophizing is a recognized phenomenon which is often considered within the context of depression. There are numerous experiments conducted for the research of pain catastrophizing and they can be broadly divided three categories according to the nature of the subjects: healthy volunteers (e.g., undergraduate students), patients with acute pain (e.g., whiplash injury after motor vehicle accidents) and patients with chronic pain (e.g., fibromyalgia and low back pain). Selected studies with their methodologies, variables and predicted outcome are summarized in Table 2.

Table 2: Summary of selected clinical studies on pain catastrophizing looking at three research sample groups: Healthy participants, acutely injury and with chronic pain

Research sample	Condition	Associated variables	Predicted outcomes and results	Comments	References
Healthy participants	None	Gender	PCS scores after catastrophizing ideation, women having higher PCS scores than men	429 undergraduates: 127 men and 302 women	Sullivan <i>et al</i> (1995) ^[9]
	None	Gender	PCS scores after cold pressor task, women having higher PCS scores than men	108 undergraduates: 53 men and 55 women	Sullivan <i>et al</i> (2000) ^[23]
	None	Gender	PCS scores after cold pressor task, women having higher PCS scores than men	80 undergraduates : 38 men and 42 women	Sullivan <i>et al</i> (2000) ^[24]
	None	Catastrophizing	Activity intolerance after delayed onset of muscular soreness—pain catastrophizing did not predict maximum strength of activity but translated to strength deficit after pain set in	50 undergraduates : 17 men, 33 women	Sullivan <i>et al</i> (2002) ^[25]
	None	Race	PCS score before and after cold pressor task, Chinese Canadians have lower pain tolerance and higher pain intensity and propensity to catastrophize	160 undergraduates: 80 Chinese Canadians and 80 European Canadians	Hsieh <i>et al</i> (2010) ^[26]
	None	Gender and race	PCS scores after cold pressor task, pain intensity, pain appraisal; men less likely to catastrophize and has higher pain tolerance, African-American more likely to catastrophize than white-Americans	155 undergraduate : 72 men and 83 women	Forsythe <i>et al</i> (2011) ^[27]
	None	Age and pain types	PCS scores, advanced age mediates association of catastrophizing with actual pain intensity	134 subjects in 2 age groups (20-40 yrs and 50-70 yrs)	Ruscheweyh <i>et al</i> (2011) ^[28]
Acutely injured	Acute whiplash	Catastrophizing and fear of movement	Pain and disability, increased catastrophizing and fear predicts higher levels of pain and disability	42 patients with daily measurements within 21 days after acute whiplash injury	Vangronsveld <i>et al</i> (2008) ^[29]
	Acute whiplash	Catastrophizing and causal beliefs	Severity of symptoms and disability monitored by questionnaires over 6 and 12 months after injury, pain catastrophizing strong predictor of current disability	140 cases identified and followed up to 12 months after whiplash injury	Buitenhuis <i>et al</i> (2008) ^[30]
	Acute whiplash	Catastrophizing and gender	Cold pain threshold, pressure pain threshold, pain levels and disability levels within 5 weeks of injury, catastrophizing associated with lower pain threshold and no gender differences in catastrophizing	37 subjects with acute whiplash injury (16 men, 21 women)	Rivest <i>et al</i> (2010) ^[31]
	Acute musculo-skeletal injury	Self-efficacy, catastrophizing and fear of movement	Pain intensity and pain-related disability, self-efficacy strongest predictor for pain and disability	Cross-sectional study with 138 subjects (46 men, 92 women) having acute musculoskeletal injury	Soderlund <i>et al</i> (2010) ^[32]
Chronic or persistent pain	Chronic musculo-skeletal pain	Gender, catastrophizing	Levels of dysfunction and rehabilitation outcome, female tend to catastrophizes more and flare less favorably	Descriptive study of 121 patients (50 men and 71 women)	Jensen <i>et al.</i> (1994) ^[33]
	Osteoarthritic knee pain	Gender and catastrophizing	Pain, pain behavior and disability, female having higher levels of pain and disability, and catastrophizing mediated the pain-gender relationship.	169 patients (72 men and 96 women) with osteoarthritic knee pain	Keefe <i>et al.</i> (2000) ^[34]
	Scleroderma	Educational level and catastrophizing	Pain and social disability, catastrophizing is associated with higher pain level among less educated, and education level mediates the relationship between catastrophizing and social function	190 questionnaires	Edwards <i>et al.</i> (2006) ^[35]
	Spinal cord injury	Catastrophizing and coping strategies	Psychological functioning and pain interference, catastrophizing strongly predicts negative pain outcomes	Mail survey from 130 individuals	Molton <i>et al.</i> (2009) ^[36]
	Chronic musculo-skeletal pain	Catastrophizing, fear of pain, pain level	Physical tolerance to lift sand-filled paint canisters, found catastrophizing translated to reduce tolerance	72 subjects	Thibault <i>et al.</i> (2008) ^[37]
	Chronic musculo-skeletal pain	Catastrophizing, fear of pain, pain level	Physical tolerance to lift sand-filled paint canisters, found catastrophizing translated to reduce tolerance	52 subjects	Gauthier <i>et al.</i> (2008) ^[38]
	Chronic pain	Self-efficacy and catastrophizing	Disability, quality of life and health, pain catastrophizing is a negative predictor while self-efficacy has a positive influence	433 patients (47 with spinal cord injury, 150 with chronic whiplash, 236 with fibromyalgia)	Borsbo <i>et al.</i> (2010) ^[39]
	Chronic low back pain	Catastrophizing	Predicted endurance and strength of low back muscle, catastrophizing associated with lower endurance and strength	27 subjects with back pain and 31 healthy controls	Lariviere <i>et al.</i> (2010) ^[40]
	Chronic low back pain	Catastrophizing and pain severity	Disability, positive correlation between back pain, referred pain, catastrophizing and disability, catastrophizing strongest predictor of disability	Cross-sectional study with 1461 patients	Kovacs <i>et al.</i> (2011) ^[41]

PCS - Pain catastrophizing scale

Per se, pain catastrophizing is an independent risk factor for predicting chronicity of pain and poorer prognosis. Van Eijsden-Besseling *et al.*^[42] performed a case-controlled cross-sectional study of work-related upper limb disorders amongst computer workers and found significant correlation of pain catastrophizing with poorer symptoms and prognosis. Bergbom *et al.*^[43] studied the prognostic factors for 297 patients diagnosed with musculoskeletal pain who received various physical therapy within 6 months and found that higher level of pain catastrophizing predicted lack of improvement and continued disability. It is fair to conclude that most studies have consistently highlighted pain catastrophizing as a predictor for physical disability in both acute injury and chronic pain conditions [Table 2].

How well does pain catastrophizing translate to physical disability?

Sullivan *et al.*^[25] recruited 50 healthy undergraduates and studied the association between pain catastrophizing and actual physical intolerance by employing the model of exercise-induced delayed onset muscle soreness (DOMS)-where participants were asked to repeat a set of concentric and eccentric contractions against heavy loads until they experienced pain, and to return for similar exercises 48 hours later for measuring any deficit in physical intolerance. The group found that pain catastrophizing did not affect the maximum physical capacity achievable in the first round of exercise, but contributed to reduction in the maximum weight that could be lifted in the second round (i.e., after pain had set in). Also, the relation remained significant after controlling for the level of pain and negative mood, signifying that pain catastrophizing alone translated to physical force deficit. Moreover, they also found that the helplessness subscale of PCS seemed to be the best predictor for disability. However, for subjects with pain, the association of pain catastrophizing with actual performance deficit lacks consensus. Crombez *et al.*^[44] studied 104 subjects with chronic low back pain and measured the association of pain-related fear, actual pain level and pain catastrophizing with performance of a physical task (Trunk-Extension-Flexion). He found that fear of pain, but not pain catastrophizing, is the best predictor of self-reported disability and performance degradation. Similar conclusion was found by Swinkels-Meewisse *et al.*^[45] who recruited 96 subjects with acute low back pain (not more than 4 weeks' duration) and studied their ability to lift a 7-kg bag repeatedly from the ground in regard to their fear of pain, actual pain levels and pain catastrophizing. However, the Sullivan camp^[37] held an opposing view. In his study of 72 subjects with chronic musculoskeletal pain, physical tolerance, communicative pain behaviors (facial and verbal expressions like grimace, grunts, words and

sighs) and protective pain behaviors (guarding, holding, touching or rubbing) were studied as the subjects sequentially lifted 18 paint canisters partially filled with sand at three standardized weights. The group found significant associations between pain catastrophizing and physical intolerance and also with both types of pain behaviors. In particular, the group found no association of fear of pain and suggested the reasons to be due to differences in patient population, parameters of tolerance task and pain measurements. In another study aimed to validate the French-Canadian version of the Pain Disability Index (PDI),^[38] Sullivan's group adopted an identical protocol of lifting sand-filled paint canisters in 52 subjects with chronic musculoskeletal pain and found association between PDI (which in turn correlated with pain catastrophizing) and reduced performance of canister lifting.

MEASURING PAIN CATASTROPHIZING: SITUATIONAL OR DISPOSITIONAL?

Being a mental set, pain catastrophizing can be assessed in two different ways—either as a reaction measured during or immediately after exposure to a noxious stimulation (situational or state assessment), or, through recall of most negative feelings and cognitions related to painful events (dispositional or trait assessment). Although pain catastrophizing is often conceptualized as a trait which is only manifests with a noxious encounter, it has been argued that dispositional assessment of pain catastrophizing often fail to correlate with actual pain ratings as the recall events(s) may either be too distal in the past or too weak in impact, or the items in the assessment tool are not rigorous enough to capture the variances. On the contrary, it is questionable that by nature of the design of the experiment, situational assessment may only partially cover the three domains of pain catastrophizing—an example being a modified form of PCS (Appendix A of original paper) used by Edwards *et al.*^[46] which seems to have omitted the magnification domain. Studies reported a varying association between the state versus dispositional assessment for pain catastrophizing: Dixon measured PCS score before (dispositional assessment) and after (situational assessment) cold pressor task in healthy subjects and found little correlation between the two;^[47] Campbell *et al.*^[48] compared situational versus dispositional PCS across multiple samples of healthy subjects, subjects with short-term pain and with chronic pain and found that except for short-term pain, there is no significant correlation between situational and dispositional pain catastrophizing in healthy subjects and patients chronic pain, and that situational PCS predicts higher pain ratings across all three groups. This calls into question

the logic and validity of studies using dispositional type of assessment for pain catastrophizing.

PAIN CATASTROPHIZING: A DISTINCT ENTITY OR REDUNDANT CONSTRUCT?

Implicit in the three domains of pain catastrophizing are negative affect constructs which are shared by a number of conditions like worry, anxiety and in particular, depression.^[49-51] The content of items measuring catastrophizing, depression and anxiety in PCS, CSQ and coping-effectiveness scale are also remarkably similar with convergent loading during factor analysis. This led to controversy whether pain catastrophizing is nothing more than a redundant construct or measurement confounds when other negative affect conditions are studied. Hirsh *et al.* administered the catastrophizing subscale of CSQ (CSQ-CAT) as a dispositional assessment to chronic pain patients and found that after regression analysis, the negative mood components of depression and anxiety were highly associated with pain catastrophizing, which when controlled for, pain catastrophizing has minimal correlation to pain prediction.^[49] George *et al.* conducted a situational measurement in healthy subjects after a cold pressor encounter using CSQ-CAT and Fear of Pain Questionnaire and found that although fear of pain associated with pain catastrophizing strongly, acute pain intensity was only predicted by fear of pain and not pain catastrophizing.^[52] This contradicted the findings of an earlier similar study by Sullivan *et al.*^[53] which stated that pain catastrophizing is a better predictor of pain ratings, although one can argue that the conclusions are not directly comparable as Sullivan employed PCS and not CSQ-CAT in his study. Since 1990's, Sullivan's group has been the stronghold in defending the conceptual and operational distinctness of pain catastrophizing from depression as a separate construct in assessing chronic pain.^[50] His view is supported by Geisser *et al.* with his dispositional study in patients with chronic pain, who concluded that catastrophizing is a separate construct that mediates the relationship between depression and the evaluative and affective effects of pain.^[54] Keefe *et al.*^[34] found a similar mediating role for catastrophizing amongst osteoarthritis patients between gender, pain, pain behavior and disability after correction for depression. In one dispositional study of subjects with persistent pain due to soft tissue injury, Sullivan *et al.* found significant correlation of PCS with reported pain intensity and perceived disability, the latter in particular seemed to be independent of the levels of depression or anxiety.^[55] Regarding possible overlap with neuroticism, Martin *et al.*^[56] found catastrophizing predicted perceived disability in patients with fibromyalgia independent of neuroticism. Thus said, other researchers still cast doubt over pain

catastrophizing as a construct distinct from negative affectivity.^[49,52] To add mud to the pond, Tuner *et al.* showed that in chronic pain sufferers, catastrophizing is a strong predictor of pain intensity^[57,58] and also in a vice versa manner with a daily process study,^[59] and that catastrophizing is a predictor of depression per se.^[60] Finally, Mounce *et al.*^[61] performed a dispositional study amongst pain-free subjects who completed nine frequently used psychometric scores which measure pain catastrophizing, negative affect, general trait anxiety, depression and anxiety, fear of illness, pain-specific anxiety, fear of pain, fear of negative evaluation and anxiety sensitivity. Component analysis of all the constructs in these nine scores revealed commonality which can be summarised into three core components: general distress, fear of pain from injury/insult and cognitive intrusion of pain which is shared by depression and pain catastrophizing. Overall evidence for pain catastrophizing as a unique construct distinct from others of negative affectivity is still conflicting, and better research methodologies and tools are needed to enable spectrum analysis of pain-catastrophizing trait in response to standardized painful event, and vice versa. Only then one can better understand the causality (if any) between the trait versus state variables.

DETERMINANTS FOR PAIN CATASTROPHIZING

Gender

So far, both dispositional and situational studies have shown a determinant effect of gender on pain catastrophizing. Sullivan *et al.* demonstrated significantly higher PCS scores in one study with female as compared to male undergraduates using catastrophizing ideation,^[9] and similarly in two another studies using cold pressor tasks,^[23,24] with differences observed in the rumination and helplessness subscales, not the magnification subscale. In a study of Swedish patients with chronic musculoskeletal pain, female tend to catastrophizes more readily than male with a less efficient coping strategy.^[33] This female predominance in pain catastrophizing is further echoed by Keefe's study with patients suffering from osteoarthritis.^[34] The exact mechanisms are still unknown but Goodin *et al.* suggested that female may possess a lower diffuse noxious inhibitory control neural circuitry which predisposes them to pain catastrophizing.^[62] Thus said, Rivest *et al.* studied patients with acute whiplash injury and found that male sex is more associated with pain catastrophizing,^[31] keeping in line with Elklit's findings that men are more prone to anxiety and disability subsequent to whiplash injury.^[63] A possible explanation being the preference of the emotion-focused coping strategy by males as compared to the symptom-focused coping strategy by the females.^[64]

Age

General consensus is still lacking regarding the effect of advanced age on pain perception, from increased sensitivity^[65-69] to reduced perception of both visceral^[70] and nonvisceral type of pain.^[71] However, one must be aware of the heterogeneity of noxious stimuli and pain assessment used in different studies which inevitable may confound the validity of results. For pain catastrophizing, data on the effects of age is very sparse and after extensive literature search, there is only one recent study by Ruscheweyh *et al.*^[28] which performed a dispositional assessment and found that in younger adults, catastrophizing is associated with emotional response to pain while in older subjects, it is preferentially associated with the actual pain intensity.

Race

There is abundant data regarding race differences in the study of pain. Compared to White-Americans, lower pain threshold and tolerance has been documented in African-Americans,^[72-75] Hispanic-Americans^[76] and South Asians.^[26] In context of pain catastrophizing, a higher association has been reported with situational assessment (cold pressor task) in Chinese-Canadians as compared to European-Canadians,^[27] and also in African-Americans as compared to White-Americans.^[77] Like that for gender, the underlying mechanisms are still unknown.

Genetic susceptibility

Seen as a trait, pain catastrophizing has been associated with specific genotypes. Geroge *et al.* found that catechol-o-methyltransferase (COMT) diplotype (high versus low activity) modulates pain ratings and pain catastrophizing in shoulder pain,^[77,78] where low COMT activity is associated with higher pain ratings and higher tendency for pain catastrophizing. In a similar context, Finan *et al.* found the val(158)met single nucleotide polymorphism in the COMT gene mediates pain catastrophizing and maladaptive pain coping in fibromyalgia.^[79] Neuropeptide S (NPS) is a recently discovered neurotransmitter produced by brainstem neurons which mediates arousal,^[80] anxiolytic responses and attenuates contextual fear.^[81] Recent data indicated that a adenosine(A) to thymidine(T) single nucleotide polymorphism on the human neuropeptide-S receptor gene (NPSR1) predisposes to catastrophizing in fear reactions.^[82] From a cell-signaling perspective, Edwards *et al.*^[83] conducted situational assessment in healthy subjects for pain catastrophizing before and after application of noxious mechanical, heat and cold stimuli, and found that higher levels of pain catastrophizing was associated with enhanced serum interleukin-6 (IL-6) activity. This putative linkage between pain catastrophizing and IL-6 need further research as to whether people with genotype

of increased IL-6 activity/production are more prone to pain catastrophizing.

Neurophysiological correlates

Pain catastrophizing is a conglomerate of maladaptive affective and cognitive responses and thanks to the advances in magnetic resonance neuroimaging techniques, in particular functional MRI (fMRI), research data have correlated pain catastrophizing with brain regions responsible for processing of pain, emotions and affect. Seminowicz *et al.* performed fMRI study on 22 healthy volunteers with electrical stimulation of median nerves and assessed their pain catastrophizing scores. Interesting, at mild levels of pain, pain catastrophizing was associated with increased fMRI activity in the prefrontal, insular, rostral anterior cingulate and parietal cortex. However, with intense pain, there was negative correlation of activity with pain catastrophizing, suggesting a failure of the top-down inhibitory from the cortex. Gracely *et al.*^[84] recruited 29 subjects with fibromyalgia and assessed their pain-catastrophizing scores after blunt stimuli. They found significant association of pain catastrophizing with increased fMRI activities in brain areas related to anticipation of pain (medial frontal cortex, cerebellum), attention to pain (dorsal ACC, dorsolateral prefrontal cortex), emotional aspects of pain (claustrum, closely connected to amygdala) and motor control. Other data have suggested an endogenous alteration of supraspinal pain-inhibitory versus pain-facilitating pathways, conceptually referred to as the diffuse noxious input controls (DNICs). DNIC is repeatedly measured as pain ratings for a “test” stimulus before and after application of a “conditioning” stimulus, and its response over time is noted. Weissman-Fogel *et al.* found that in healthy subjects pain catastrophizing is associated with a lower DNIC profile,^[85] and such findings were replicated by Goodin *et al.*^[62] who also added that female gender also seems to have a lower DNIC. Finally, one recent study by Quartana *et al.*^[86] showed flattening of the morning cortisol profile which was associated with pain catastrophizing irrespective of the actual pain status. This implies a possible endogenous neurohormonal basis for pain catastrophizing as a trait.

Psychosocial variables

Being a negative mental and affective set, pain catastrophizing would in theory be exacerbated by adverse or unstable psychosocial settings. Meredith *et al.*^[87] recruited pain-free subjects and studied the effects of adult attachment styles on emotions, cognitions, pain tolerance, pain intensity and pain catastrophizing during and after a cold pressor task. It was found that adult attachment style mediates the impact of pain intensity on tendency to catastrophize, and insecure attachment leads to higher pain scores

and likelihood to pain catastrophizing, while secure attachment was associated with better pain control, lower level of depression and pain catastrophizing. In the same vein but using different methodologies, McWilliams *et al.*^[88] asked university students to complete a battery of psychometric measures including PCS and studied the impact of adult attachment on pain-related fear, pain hypervigilance and pain catastrophizing. It was found that rejection anxiety and beliefs of personal unworthiness associated with fear avoidance while discomfort with intimacy and interpersonal mistrust is linked strongly with pain catastrophizing.

THEORIES FOR PAIN CATASTROPHIZING AND APPROACH ANALYSIS

Attention-bias model

The attention bias models states that pain catastrophizing results of a preferential and dysfunctional bias of attention toward pain and its related cognition and mental processes. Taken for grant as a normal human reaction, any painful stimulus interrupts and demands attention of the subject. Eccleston *et al.* elaborated a model consisting of seven components (environment, multiple demands from the environment, sensory system, action programs, focal task, threat mediation and moderating factors) to address why and how pain interrupts attention to motivate an urge to escape.^[89] He opined that the interruptive function of pain depends on the pain-related characteristics (e.g., threat level of pain) and the environmental demands (e.g., emotional arousal). Authors did mention briefly that pain catastrophizing is a variable of pain characteristics in the interruptive process; hence pain catastrophizers may have their attention maladaptively interrupted to a state of cognitive and behavioral immobilization whenever a painful stimulus occurs. Using a cueing paradigm, Van Damme *et al.*^[90,91] found that subjects who score higher in self-reported pain catastrophizing scores tend to have either exaggerated attentional engagement, retarded attentional disengagement, or both to painful stimuli. Vancleef *et al.*^[92] asked healthy volunteers who had been prescreened with Pain Catastrophizing Scale, the Anxiety Sensitivity Index, and the Injury/illness Sensitivity Index and measure their attentional interference as they perform an auditory discrimination task whilst occasional distracted by low electrocutaneous stimulations. It was found that only pain catastrophizing enhances interference of their attentional ability. In an attempt to tweak attention to modulate pain catastrophizing, Michael *et al.*^[93] subjected volunteers to an initial cold pressor task and then ask them to read out a serious of control, pain-sensory and pain-affect words whilst undergoing a second cold pressor task. As expected,

reading affect-related words, but not the other words, led to higher pain catastrophizing in the second task. In a similar line of thought, Quartana *et al.*^[94] recruited subjects with chronic low back pain and manipulated their attention either by distraction or suppression strategies, and found that pain catastrophizing was strongly related to suppression (i.e., enhanced attention) and alleviated by distraction (i.e., reduced attention).

Schema-activation model

Sullivan *et al.*^[9,95] proposed that pain catastrophizers possess a special pain schema which consisted of a distorted cognition with excessively pessimistic beliefs about pain, pain-related experiences and actual ability to cope. When confronted with the minimally noxious stimulus, this schema is activated and heightens the pain experience which eventually over time, translates to a learned expectancy (or self-fulfilled prophecy) regarding the high threat of pain and their own inability of management. This model is strong in explaining the cognitive processes that contribute to pain catastrophizing but do not address the conditions and their interactions that lead to activation of the schema. Also existing methodologies cannot test whether and to what degree the schema has been activated during the pain-catastrophizing process.

Appraisal model

The appraisal model evolves from the transactional model of stress and coping put forward by Lazarus and Folkman. Whenever a pain stressor comes along, the subject initially assess the relevance and levels of harm as the primary appraisal, then continue to contemplate upon the coping options and formulate the beliefs regarding the possibility of success as the secondary appraisal. In the context of pain catastrophizing, researchers proposed that magnification and rumination domain stems from a dysfunctional focus and evaluation in the primary appraisal stage, while helplessness is a maladaptive and negative secondary appraisal.^[96] In a study of professional dancers who are sued to cope with pain due to performance or injury,^[97] Anderson *et al.* found that their appraisal of pain did not differ according to the type or severity of pain they experience, except when perceived as a threat, would associate with pain-catastrophizing behavior.

Communal coping model

Advocated by Sullivan *et al.*, the communal coping model states that pain catastrophizing is a behavior strategy of coping where subjects communicate their painful experience to elicit emotional and social support from others, hence reinforcing the pain and illness behavior and subsequently undermining their normal adaptability to cope with the pain itself.^[95] Living

with a partner or spouse leads to higher probability of catastrophizing for subjects with chronic pain,^[98] and the partners or spouse would also perceive higher pain levels from the pain catastrophizers and provide more instrumental support.^[99] In a related manner, greater perceived entitlement to pain-related support was more associated with pain catastrophizing.^[100] However, such dynamics may be far from pleasant as the expressions of pain by pain catastrophizers, although on one hand solicit support and compassionate proximity, may actually lead to punitive interpersonal responses and relationship conflicts.^[99,101-103] Cano *et al.*^[103] recruited married individuals with chronic pain and via hierarchical regression analysis, they found that positive support responses were associated with short period of pain while negative responses with longer pain period. On a broader interpersonal scale, Lackner *et al.*^[104] performed circumplex analysis on interpersonal behavior and proposed that pain-catastrophizing stems from a submissive interpersonal style with high dependency and demand for care and support. Having said, Severeijns *et al.*^[96] queried the need of this communal coping model for pain catastrophizing as according to the appraisal model, the three domains of ruminative thinking, magnification of pain and feeling of helplessness will impinge upon subsequent interpersonal and support mechanisms, hence making the communal coping model redundant.

CAN PAIN MODELS EXPLAIN PAIN CATASTROPHIZING?

Transactional model of stress

First described in 1980's by Lazarus and Folkman,^[105] stress is viewed as a relational product between the person and the environment, and stress arises when the individual judges that the environmental demands exceed the individual's own resources.^[106] It involves two appraisal processes: the primary appraisal occurs when the individual makes sense of the encounter and determines its nature as challenging, harmful or threatening; the secondary appraisal evaluates the coping resources and decides on what can be done.^[107] It has been shown in patients with fibromyalgia, the level of perceived stress has a significant bearing on the symptoms severity and illness impact, lending support to this transactional model which states that when pain (stressor) is initially appraised as way beyond the individual's coping mechanisms, then secondary appraisal as to what can be done will be defective and the individual will felt helpless and pessimistic without a solution and revert to primary appraisal of the stressor in a detrimental feedback loop, resulting in a positive amplification of the pain sensation and gravity of the problem—hence catastrophizing.

Self-regulation model

Proposed by Carver *et al.* in 1982,^[108] the self-regulation model states that the human mind will identify goals to modify mentation, volition and tasks performance in face of a challenge or adversity to attain more desirable outcomes.^[109] These outcomes include better mental health against the threat of mortality,^[110] adherence to law, standards and norms, proactive coping skills^[111] especially in poverty,^[112,113] maintaining adult attachment relationships and their salvage,^[114] academic goals attainment,^[115,116] abstinence from substance addiction^[117] and also protective effects against disordered eating.^[118] Moreover, some researchers consider self-regulation as an adaptive capacity which can be trained up with repeated exercises^[119,120] of both the mind and the body, with the added concept that it is a limited resource dependent upon blood sugar^[121] and physical stamina. According to this model, self-regulation it is likely to fail with ego depletion,^[122,123] which happens when multiple self-regulation activities ended in unattained goals and drained the ego and related limited resources, hence aborting further goal-directed self-regulatory ability on subsequent tasks.^[122,123] In the context of pain catastrophizing, the subject encountered the painful experience and identified goals to self-regulate but repeatedly made futile attempts, which then depleted the limited resources of the ego and the physique, hence lapsed into a state of pessimism and helplessness due to goal failure, culminating in an exaggerated response to both the extent of the pain and the gravity of the problem.

Gate control theory and neuromatrix theory

First described by Melzack and Wall in 1965, the gate-control theory^[124,125] is an epoch-marking theory in the field of neuroscience which states that pain signals, as primarily mediated by the A- δ and C-fibers, can be modulated by intermediate interneurons which act as gates either to enhance or suppress the pain signal *per se*. These interneurons may originate at the laminar level or from higher centres of the central nervous system. Crude as it may sound, this gate-control theory pioneered the fundamental concept of modulatory pain pathways by neurons which are not nociceptive by nature. This gate-control theory remained unchallenged in the following 40 years, only to be refined by Melzack himself to the neuromatrix model,^[126-128] which incorporated the essential domains of cognition and emotion *pari passu* with sensory inputs to form a dynamic body-self matrix which in turn generated a neurosignature manifested either as nociception, motor activity or autonomic/immune self-regulatory responses [Figure 3] One important feature of this model is that the neuromatrix is incessant and sensory input is not essential for generation of a neurosignature. This provide an explanation for most,

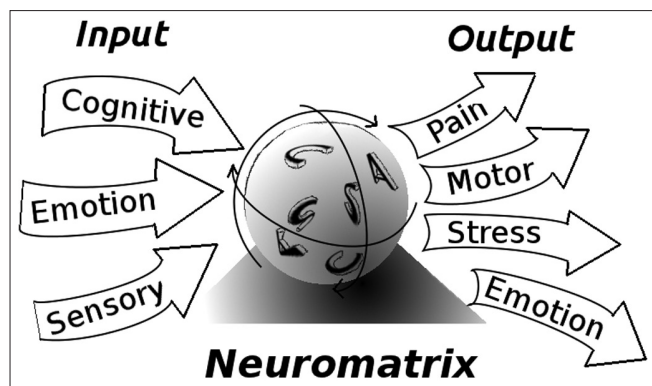


Figure 3: Conceptual diagram of the neuromatrix theory as a refinement of the gate-control theory. Itself visualized as an entity (like an incessant spinning sphere) comprising of the somatosensory (S), cognitive (C) and affective (A) domains, the neuromatrix receives inputs from areas of the brain governing sensation, emotions and cognitions; and in return, churns out a neurosignature (output) which activates various programs for pain recognition, motor response, emotional and stress reactions. (Adapted from Melzack, Evolution of the neuromatrix theory of pain. The Prithvi Raj Lecture: presented at the third World Congress of World Institute of Pain, Barcelona 2004. Pain Pract 2005;5:85-94.)

if not all scenarios of chronic and neuropathic pain where noxious sensory input is invariably absent from the equation. In the context of pain catastrophizing, the cognitive and emotional domains of input become so dominating that the neuromatrix outputs become disproportionate and maladaptive.

Conclusions and food for thought

Pain catastrophizing is a specific mindset with direct impact on the subject's behavior, functional ability and quality of living. One questionnaire study on healthy volunteers asking them to reflect on past painful experiences suggest that pain catastrophizing tendency may be pain-type specific and may associate with emotional responses to pain in younger subjects as compared to association with the actual pain intensity in older subjects.^[28] On one hand, with its determinants like female sex, Asia/African race, age, certain genotypes and hormonal/neurophysiological phenotypes, pain catastrophizing can be regarded as a trait which will manifest with situational challenge. On the other hand, against a background of chronic pain, pain catastrophizing also function as a variable which can alter the prognosis and level of physical disability. Our understanding of pain catastrophizing may well be summarized as a black-box--we have good knowledge of the inputs and outputs but the processes and mechanisms that constitute the box are still unclear. Moreover, experimental attempt to manipulate the process of pain catastrophizing has concluded without success.^[129] Martorella *et al.* reviewed 51 publications on pain catastrophizing and performed a dimensional conceptual analysis^[130] with the conclusion that our present knowledge seems to reach a middle-range theory

with a focus on relating pain catastrophizing with two or more concepts aiming for prevention and cure. However, there is still a logical snag: from a philosophical perspective, pain is always an internal subjective sensation which despite numerical or graphical rating, remains a feeling uniquely relating to the individual. When we attempt to use descriptives to represent the feeling in a logical form, it is instantaneously constraint by the lexicographic rules and logic implicit in the words used, which in turn would differ tremendously between different languages. Quoting the logic of famous philosopher Ludwig Wittgenstein: "the limits of my language means the limits of my world" (Tractatus: 5.6) and, "we cannot think what we cannot think; so what we cannot think we cannot say either" (Tractatus: 5.61).^[131] Hence, using a reference scoring tool like the PCS to assess the complex mental set of pain catastrophizing will philosophically distort the true nature and limit the boundary of its ramifying affectivity and cognitions. Also trying to describe a mindset that is not experienced or contained in the own self is always a logical and philosophical debate, albeit how scientifically rigorous it would seem.

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