Some Words Hurt More Than Others: Semantic Activation of Pain Concepts in Memory and Subsequent Experiences of Pain

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Abstract: Theory suggests that as activation of pain concepts in memory increases, so too does subsequent pain perception. Previously, researchers have found that activating pain concepts in memory increases pain perception of subsequent painful stimuli, relative to neutral information. However, they have not attempted to quantify the nature of the association between information studied and ensuing pain perception. We subliminally presented words that had either a low or high degree of association to the word 'pain,' although this was only partially successful and some words were consciously perceived. Participants then received randomized laser heat stimuli, delivered at 1 of 3 intensity levels (low, moderate, high), and we measured the effect of this on behavioral and electrophysiological measures of pain. Participants (N = 27) rated moderate- and high-intensity laser stimuli as more painful after viewing high relative to low associates of pain; these effects remained present when we controlled for measures of mood, anxiety, and physical symptom reporting. Similar effects were observed physiologically, with higher stimulus negativity preceding after high relative to low associates and greater amplitudes for the N2 component of the laser-evoked potential after presentation of high associates in the moderate and high laser intensity conditions. These data support activation-based models of the effects of memory on pain perception.

Perspective: Consistent with current theories of memory and pain, we found that high, relative to low activation of pain concepts in memory increased psychological and physiological responses to laser-induced pain. The effect remained regardless of whether participants showed conscious awareness of activation. Theoretical and clinical implications are discussed.

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Key words: Pain, memory, priming, electroencephalography.

Memory has been cited to play an important role in the perception of pain and the development and maintenance of chronic pain conditions.[5,16,22,65] Theory suggests that memory processes might be particularly relevant to understanding pain that occurs in the absence of noxious stimulation or peripheral pain pathology. According to Brown,[14] for example, such "unexplained" pain can result from the chronic activation of pain-related information in memory. A number of sources for this chronic activation have been hypothesized, including pain-related illness behavior, worrying and ruminating about one's own and others' painful experiences, and repeated exposure to pain messages in the family, media, and elsewhere. Activation of pain-related information in memory might also bias the individual to look for, notice, and respond to pain-related information within the wider environment, which sets up a vicious cycle. Activation of pain-related information in memory is thought to be common to everyone and largely unconscious. That information might enter the cognitive system and influence behaviors such as symptom experiencing and responding without conscious awareness (ie, subliminally) is central to the model, which was essentially intended to explain

how medically unexplained symptoms (pain being a common one) can arise in the absence of defined medical or psychiatric pathology.

In support of this model, there is evidence that noxious stimuli are rated as more painful after participants have been exposed to (or 'primed' by) supraliminal pain-related pictures rather than neutral pictures.[23,48,53] Physiological effects have also been shown using electroencephalography (EEG) with larger N2 to P2 peak-to-peak amplitudes for laser evoked potentials (LEPs) after supraliminal presentation of pain-related words relative to neutral words.[77] Consistent with the assertion that activation of pain-related information can also occur unconsciously, Meerman and colleagues[51] found lower pain tolerance after exposure to subliminally presented health-complaint words relative to neutral words. However, subsequent attempts to replicate this effect have been unsuccessful.[49,50]

Although they provide some support for the effect of memory activation on pain perception, there are a number of problems with studies in this area. For example, researchers have not attempted to quantify the degree of semantic association between materials (or cues) presented at study and the subsequent activation of pain-related concepts in memory; for example, in the studies by Meerman et al,[49-51] to what degree were health complaint words more closely related to semantic networks for pain than neutral words? This is crucial because Brown's model[14] predicts that increased semantic activation of pain-related memory networks has a direct relationship with ensuing pain. Moreover, stimuli were not always matched on important dimensions such as arousal or valence, which could have had a significant effect on pain ratings.

To this end, in the current study we examined behavioral and physiological responses to painful laser stimuli after the subliminal presentation of words that shared either a low or high degree of association to the word, 'pain.' We expected higher subjective pain ratings, as well as increased electrophysiological activity consistent with the processing of painful stimuli, in the high associate conditions. In Brown's model it is proposed that the activation of pain-related concepts in memory is a normal cognitive process. It was therefore hypothesized that these effects would be present even when we controlled for various measures of mood and anxiety. However, it was also expected that there would be a positive correlation between physical symptom reporting and the priming effect, on the grounds that high symptom reporters are likely to have a lower threshold of activation for pain-related concepts in memory.

Methods

Participants

Twenty-seven healthy and currently pain-free participants (19 female, 8 male; mean age = 24.91 years, SD = 4.0 years) were included in the study. All participants were right-handed and reported being free of neurological or other conditions that affect pain perception. None

of the participants were taking pain medication at the time of the study. The study was approved by the Manchester University Research Ethics Committee and participants gave written and informed consent. Participants were told what would happen to them during the study but they were not told about the use of subliminal priming so as to keep the processing of pain associates subconscious. All participants were fully debriefed at the end of the study. Data were collected between January and May, 2014.

Materials and Measures

Associates of Pain

We decided to use low versus high, rather than neutral versus high, associates of pain because a number of studies have already reported the differential effects of neutral versus pain or health-related materials on ensuing pain perception.[23,48,51,77] Furthermore, because Brown's model[14] stipulates that the degree of semantic association between associates presented at study and pain-related networks in memory has a direct relationship with pain experience, it was essential that we measure this. Although the degree of association between neutral associates and pain-related memory networks might be expected to be very low, relevant data are not available, to our knowledge.

Sixteen semantic associates of the word, pain were chosen from the University of Florida Free Association Norms (Florida word norms).[57] The Florida word norms is the largest database of word norms in the world, with data from more than 6,000 participants. The database provides cue-to-target probabilities that index the likelihood that one word will bring another (in this case, pain) to mind in the absence of any other information or constraints. Cue to target probabilities provide a measure of the accessibility, and therefore the activation of, semantically related words in memory.[33,60] The database has been shown to be reliable overall (r = .89).[56] Eight high associates and 8 low associates were selected (Appendix A). Cue to target probabilities ranged from .64 to .25 for the high associates and .05 to .01 for low associates. High and low associates significantly varied in the probability with which they brought the target word, pain, to mind (t_{14} = −8.99, P < .001). High and low associates were matched for length (t_{14} = −.13, P = .90), frequency (t_{14} = 1.19, P = .26), emotional valence (t_{14} = 1.53, P = .15), and emotional arousal (t_{14} = .12, P = .91).

Recognition Test

A recognition test comprised of all 16 associates, 8 related lures (ie, words related to pain that were not presented during experimental trials), the critical lure (ie, pain), and 8 unrelated lures acted as an awareness check to determine whether associates had been processed subliminally. It also provided information on the types of memories participants had for low and high associates as well as their ability to discriminate targets from false alarms (ie, sensitivity) and their response criterion (ie,