Effects of Psychological State on Pain Perception in the Dental Environment

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ABSTRACT

Psychological factors have an important influence on pain perception. Both in the clinic and in experimental settings, distraction has been shown to reduce pain. Further, negative emotions increase pain, whereas positive emotions have the opposite effect. Other more complex psychological states alter the way we feel pain. For instance, empathy for another person who is suffering increases our own pain experience, and expectation of pain relief underlies much of the placebo effect. Neuroimaging studies show a physiological basis for psychological pain modulation, with activity in pain pathways altered by attentional state, positive and negative emotions, empathy and the administration of a placebo. The same psychological factors activate intrinsic modulatory systems in the brain, including those stimulated when opiates are given for pain relief. It is important for the dentist and patients to understand the influence of psychological state on pain transmission. Such an understanding will not only help patients learn how to participate in their own pain control, but will also help the clinician create a fostering environment.

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Most clinicians probably notice a dramatic difference among patients in terms of the pain they report during and after dental procedures. For example, when patients undergoing third molar extraction are allowed to vary their degree of sedation according to the amount of stress caused by the procedure ("patient-controlled sedation"), some make very few or no sedation requests, whereas others request sedation more than 60 times during the surgery.[1] Are some patients more demonstrative than others, or does the pain experience actually differ from person to person? A number of factors can contribute to a person's pain experience, including genetic makeup, age, gender and life experiences, but one of the most important factors is the individual's psychological state at the time of the painful experience. In this article, we address how a patient's psychological state can affect his or her pain perception and the neurophysiologic basis of the psychological modulation of pain.

Despite a plethora of anecdotal accounts about people apparently experiencing little or no pain in situations that most of us would find intolerable, Western medicine generally fails to address a patient's ability to modify pain, focusing instead on pharmacologic treatments. Consistent with this attitude, most research on pain control has targeted peripheral and spinal cord mechanisms of opioid and anti-inflammatory analgesic therapy.

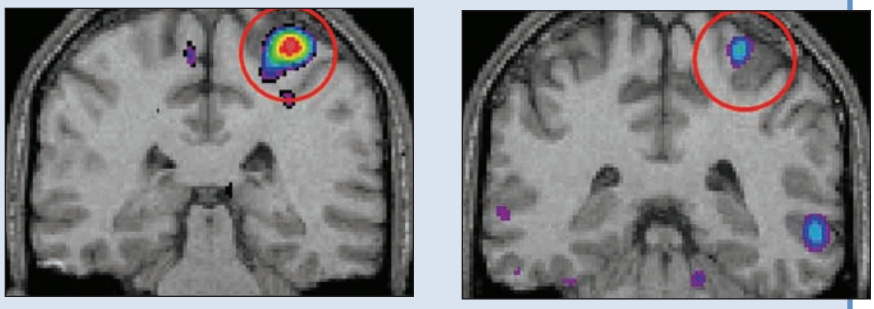

Figure 1: Activity in the primary somatosensory cortex when a painful heat stimulus and an auditory tone are presented simultaneously. Pain-related brain activations appear stronger when attention is directed to the painful heat stimulus (**left**) than to the auditory stimulus (**right**), suggesting that reductions in pain ratings during distraction from the noxious stimulus reflect real reductions in perceived pain. Brain activations were revealed by subtracting positron emission tomography data recorded when a warm stimulus (32–38°C) was presented from those recorded when a painfully hot stimulus (46.5–48.5°C) was presented during each attentional state. (Adapted with permission from Bushnell and others.[7])

Nevertheless, researchers increasingly recognize that a variety of pain modulatory mechanisms exists within the nervous system, and these can be accessed either pharmacologically or through contextual or psychological manipulation.[2] Variables such as attentional state, emotional context, empathy, hypnotic suggestions, attitudes and expectations, including the placebo response, have now been shown to alter both pain processing in the brain and pain perception. Techniques that modify these variables can preferentially alter sensory or affective aspects of pain perception or both; the associated modulation of pain-evoked neural activity occurs in limbic or sensory brain regions, or both, suggesting multiple endogenous pain-modulatory systems.

Attentional State Alters Pain

Attention is probably the most widely studied psychological variable that modifies the pain experience. A number of clinical and experimental studies show that pain is less intense when a person is distracted.[3,4] Overall, when people are distracted from the noxious stimulation, they report significantly lower ratings of pain. However, a few studies indicate that focusing attention on certain aspects of the pain may have the paradoxical effect of reducing its perceived intensity in certain individuals. For example, Hadjistavropoulos and others[5] observed that patients with chronic pain who were particularly health-anxious reported less anxiety and pain when they focused on the physical sensations. Thus, the effect of attention or distraction on pain may not be simple, but may be influenced by such variables as personality type.

In some studies,[6] patients have been asked to rate separately how intense the pain sensation is (pain intensity) and how much it bothers them (pain unpleasantness). These studies show that attending to another sensory modality during pain results in parallel reductions in both perceived intensity and unpleasantness of the pain, sometimes with greater modulation of pain intensity. Correspondingly, attention-related modulation of pain-evoked neural activity has been observed in pain pathways throughout the brain using neuroimaging techniques, such as functional magnetic resonance imaging and positron emission tomography. (Both techniques detect variations in neural activity indirectly, via the associated vascular responses, i.e., they measure the increase or decrease in regional cerebral blood flow, which occurs within a few seconds of the onset of a localized increase or decrease in neural activity.)

At the level of the cerebral cortex, imaging studies show that distraction from pain reduces pain-evoked neural responses in both sensory and limbic cortical areas, including primary and secondary somatosensory cortices (involved in encoding stimulus intensity and location), anterior cingulate cortex and insular cortex (more consistently involved in encoding stimulus aversiveness).[3] **Figure 1** shows greater activation of the primary somatosensory cortex by pain when the subjects are required to pay attention to the pain than when they focus their attention on an auditory stimulus. Thus, simply distracting a patient from his or her pain can have a profound effect on how the pain is processed in the brain and, consequently, on how it is perceived.

Our Emotions Affect Our Pain

Mood and emotional state also affect pain perception, with negative emotions leading to more pain than positive emotions. Clinical studies show that emotional states and attitudes of patients influence pain associated with chronic diseases.[8] For instance, depressed cardiac patients have greater perception of anginal pain (i.e., display an earlier onset and a more prolonged duration of angina) than nondepressed patients, which cannot be explained by differences in the severity of cardiac condition.[9] In patients with chronic pain, self reports of pain were significantly correlated with self reports of depressive symptoms and global affective distress.[10] This is also true for acute pain in the dental environment, where the level of preoperative anxiety has been shown to be posi-

tively correlated with postoperative pain immediately after preprosthetic oral surgery.[11]

In experimental studies, manipulations that have a positive effect on mood or emotional state, such as pleasant music, odours, pictures and humorous films, generally reduce pain perception, whereas those that have a negative effect on mood and induce negative emotions, such as anxiety, increase pain.[4] One problem encountered in the dental office is the often impregnating odour of eugenol, which is sufficient to produce autonomic responses consistent with fear, anger and disgust in patients who fear dental care and, thus, contributes to the strengthening of negative conditioning toward dental care.[12] The possibility of masking it with a pleasant and relaxing odour such as lavender or orange could be considered.[12,13]

By What Mechanisms Do Attention and Emotions Alter Pain?

The neural circuits involved in attentional and emotional modulation of pain are not fully known, but most likely involve various levels of the central nervous system. An opiate-sensitive descending pathway from the frontal cortex to the amygdala, periaqueductal gray matter (PAG), rostral ventral medulla and spinal cord dorsal horn has been implicated in psychological modulation of pain.[2] Some researchers have suggested that this pathway is involved in attentional modulation of pain, but these studies have usually used tasks that alter emotions as well as attention.

For example, Valet and colleagues[14] reported activation of the frontal cortex–PAG pathway when patients were distracted from their pain. However, they used the Stroop task as the distractor. In this task, subjects are presented with a list of colour names (e.g., green, blue), in which each word is displayed in a colour different from that expressed by the word's meaning (e.g., the word blue may be written in green ink). The subject's task is to name the colour in which each word is displayed, rather than the word itself. Although this task is distracting, it is also stressful and increases arousal. Thus, both emotional and attentional states were probably altered.

In our laboratory, we have used odours to manipulate attention to pain and emotional state independently and found that the PAG is preferentially implicated in emotional modulation of pain, whereas the superior posterior parietal cortex is more important in attentional modulation.[15]

How Can the Dentist Use Attention and Emotions to Reduce a Patient's Pain?

Both distraction and a positive emotional state alter pain, and they do so through separate modulatory systems. Thus, any activity that both diverts attention from a painful procedure and helps improve a patient's emotional state could be useful in a dental setting.

Dental procedures are often a source of anxiety in patients. The prevalence of dental anxiety in the general population ranges from 4% to 20%, independent of ethnic, social and cultural background, and its incidence is not reduced by improving dental treatment.[16] Because anxiety and stress increase pain perception, it seems important to use interventions that reduce anxiety and improve mood, in addition to distracting the patient. A number of methods can easily be implemented in the dental clinic setting, including playing music, showing humorous films on a monitor installed above the dental chair (or with a virtual reality eye-glasses system) or filling the room with pleasant odours. Such methods have been shown to be effective in reducing dental pain in some patients.[13,17,18]

However, it is important to keep in mind that not everybody responds equally well to the same behavioural strategy. For example, some authors found that both a brief relaxation method and music-induced distraction reduced dental anxiety significantly, but the relaxation method was particularly effective in highly anxious patients, whereas the music distraction did not have a clinically relevant effect on these patients.[19] Therefore, it would appear that gathering information on a patient's personality traits before surgery might help the clinician choose the most effective nonpharmacologic strategy for pain and anxiety control.

Providing accurate preparatory information before medical and dental procedures is a useful strategy to reduce the anxiety-related exacerbation of pain. In particular, providing preoperative information that includes a description of both the sensations that the patient will likely experience and the sequence of medical procedures has been found to yield the strongest and most consistent benefits in terms of reducing negative affect, pain reports and distress (compared with describing either sensory or procedural information alone).[20]

Finally, engaging patients in distracting activities during the postsurgical recovery period might also be beneficial. Levine and colleagues[21] observed that patients who underwent surgical removal of upper and lower third molars reported higher ratings of postsurgical pain if they were asked to express their ratings more frequently (every 20 minutes) than less frequently (every hour).

Social Influences on Pain

Although pain is commonly referred to as a private experience, research shows that social interaction influences how we perceive and communicate our pain. For example, the mere presence of another person in pain can modify our pain behaviour by promoting a form of imitative learning termed "social modeling." When patients are tested in a room with another person receiving

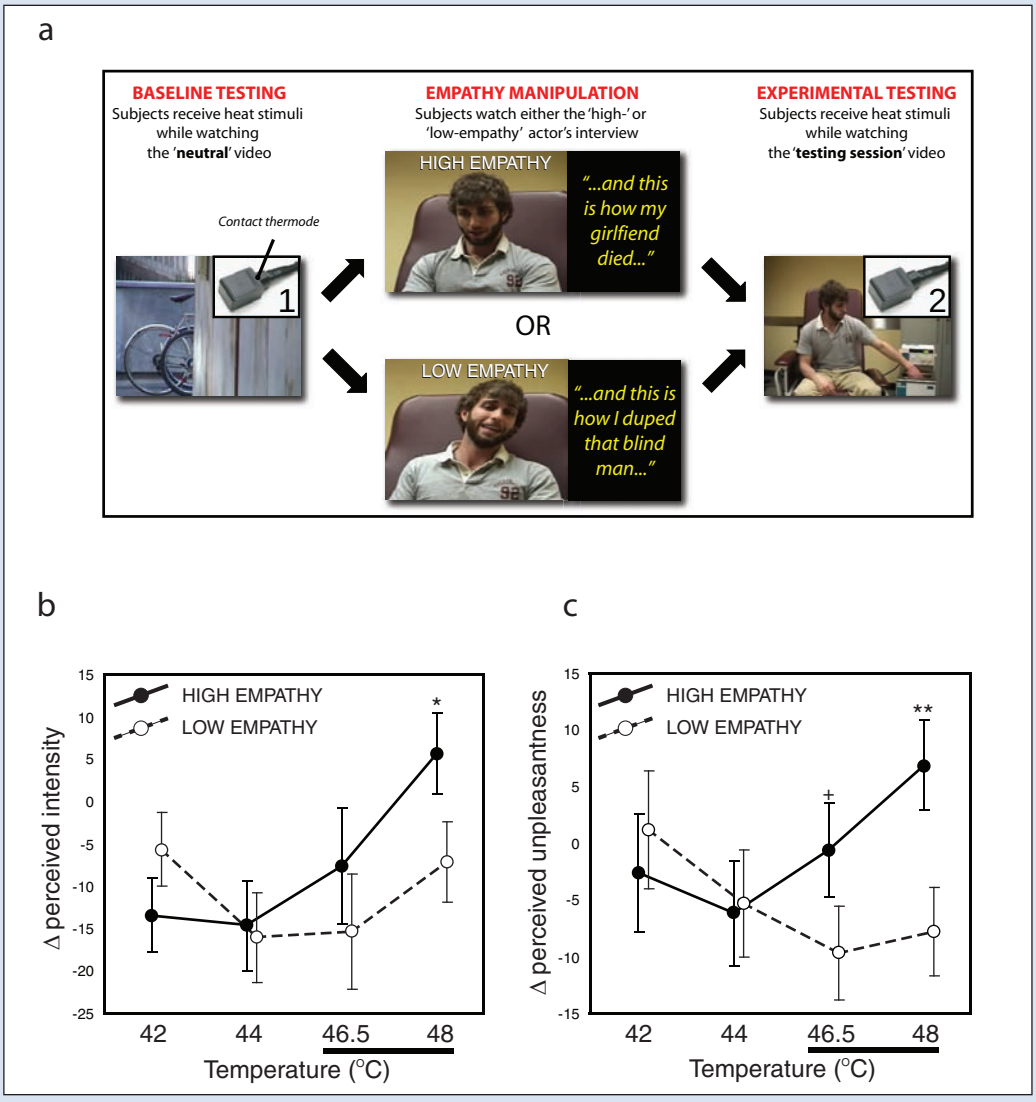

Figure 2a: Design of a study by Loggia and others[26]: Participants' sensitivity to nonpainful and painful heat stimuli was measured during their exposure to a neutral cityscape video. Half (high-empathy group) were then shown a video of an actor telling a sad personal story; the other half (low-empathy group) were shown a non-empathetic story. Thermal sensitivity was measured again while participants watched the video of the actor while receiving painful or innocuous heat stimuli.

Figure 2b and c: Effects of empathy on pain perception. Empathy increased perceived intensity (**b**) and unpleasantness (**c**) of painful but not of nonpainful stimuli. High-empathy participants reported the 48°C stimulus as more intense ($p < 0.05$) and unpleasant ($p < 0.01$) than low-empathy participants. Graphs show the average rating for each temperature while the participants watched the "testing video" minus the baseline rating recorded while the participants watched the neutral cityscape video. Bars represent mean ± standard error of the mean. + indicates $p = 0.06$, * indicates $p < 0.05$, ** indicates $p < 0.01$. (Adapted with permission from Loggia and others.[26])

painful stimulation, they will increase or decrease their pain behaviour to match that of the other person.[22]

People around us can also influence our pain behaviour by their attitude toward our pain. Illness or pain behaviour can be inadvertently reinforced if their occurrence is accompanied by some kind of "reward," such as special attention or the opportunity to avoid unpleasant situations. For instance, solicitous attention from parents predicts slower recovery from oral surgery in adolescent patients,[23] and the amount of parental attention predicts the intensity of recurrent abdominal pain in children.[24]

"I Feel Your Pain": An Empathetic Patient May Feel More Pain

There is now evidence that witnessing the distress of others can alter pain perception, independent of imitative behaviour. Langford and colleagues[25] showed that if a mouse is exposed to another mouse in pain, it displays increased pain sensitivity, but only if the 2 mice have had previous social contact with each other. The authors provided evidence that this social modulation of pain cannot be explained by imitation and proposed that empathy, or a precursory form of it, can induce an increase in pain perception.

A similar phenomenon has been shown in humans.[26] Participants were shown videos that induced a state of either high or low empathy. Subjects in the high-empathy group rated painful heat stimuli as more intense and unpleasant than those in the low-empathy group, but ratings of nonpainful heat did not differ between the groups (**Fig. 2**). As with the mice, the increased pain could not be explained by imitative behaviour.

Why does empathizing with others affect our own pain perception? A number of brain imaging studies have shown that watching another person in pain leads to the activation of brain areas involved in first-person perception of pain, such as the anterior cingulate cortex and rostral insula.[27] It appears that empathy sensitizes pain pathways of the brain. Thus, in the dental office, keeping waiting patients away from the sight and sounds of other dental patients might be an important measure to reduce pain.

Placebo and Orofacial Pain

Psychosocial factors, such as faith in the therapeutic procedure or desire for pain relief, contribute to the effectiveness of any medical treatment. In the clinical setting, it is difficult to dissect the relative contribution to the treatment response of pharmacologic versus psychosocial factors. However, the use of a sham treatment (placebo) can disentangle these effects. Brain imaging has been tremendously useful in establishing that placebo analgesia is indeed "real," by showing that placebo-induced pain relief is associated with a concomitant decrease in brain activity in pain-processing areas such as the thalamus and the insular cortex (**Fig. 3**).[28] This means that reported pain reductions following placebos are real effects rather than merely due to changes in pain reporting or compliance with experimental instructions.

How Do Placebos Exert Their Analgesic Effects?

Almost 30 years ago, Levine and colleagues[29] showed that pain relief induced by administration of a placebo after dental surgery could be blocked by the opioid-receptor antagonist naloxone. Since then, numerous reports have supported the idea that endogenous opioids are important in placebo analgesia. Endogenous opioids are essential for the descending inhibitory control of pain. The brainstem PAG and rostroventral medulla are 2 key areas for descending pain control[2] and, as we discussed above, this circuitry is probably involved in the emotional modulation of pain. These regions project to the spinal cord and trigeminal nuclei and inhibit incoming nociceptive signals. Human imaging studies show increased activation of brainstem structures during placebo analgesia, and the anterior cingulate and prefrontal cortices, which are activated by placebo procedures, may play a role in placebo analgesia by tapping into the descending pain inhibitory system via their projections to the PAG.[28]

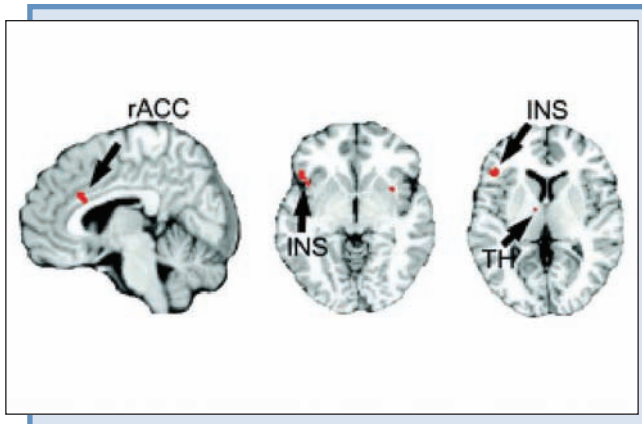

Figure 3: Pain regions displaying lower activity when patients report placebo-induced reductions in pain. When painful shock was presented to the participants, the rostral anterior cingulate cortex (rACC) was activated more during the control condition than during placebo (**left**). Similar effects were observed in insular cortex (INS) and thalamus (TH) (**middle** and **right**). These observations suggest that the reductions in pain reported by those receiving a placebo are associated with the dampening of neural pain-related activity and, therefore, cannot be explained in terms of response bias. (Adapted with permission from Wager and others.[28])

Conclusion

There is now extensive evidence that psychological factors influence pain perception. Neuroimaging studies show that activity in pain pathways is altered by attentional state, positive and negative emotions, stress, empathy and the administration of a placebo. The same psychological factors activate intrinsic modulatory systems in the brain, including those stimulated when opiates are given for pain relief. It is important for both the patient and the clinician to be aware of the effect of psychological state on pain transmission, so that the patient can learn to participate in his or her own pain control and the clinician can create an environment that helps the patient reduce anxiety, improve mood and focus attention away from the pain.

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