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# The Benefits of Pain

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**Abstract** Pain is most often an unpleasant experience that alerts us to actual or possible tissue damage. However, insisting that pain is always bad news may hinder understanding of pain's many facets. Despite its unpleasantness – or perhaps because of it – pain is known to enhance the perceived value of certain activities, such as punishment or endurance sports. Here, we review evidence for a series of mechanisms involved in putative benefits of pain. A byproduct of pain's attention-grabbing quality can be enhanced perception of concurrent pleasurable stimuli. This is thought to explain why pain may augment the pleasure of spicy foods. By providing an aversive contrast, pain can also improve the experience of events that follow pain's offset and lead to pleasant relief. Other potential benefits of pain derive from its ability to inhibit other unpleasant experiences and to elicit empathy and social support. The experience of pain can benefit our defence systems, since pain can enhance motivation to accumulate resources such as social support and calorie-rich foods. It can also reduce the guilt we feel after self-indulgence or moral transgressions. In sum, we highlight a series of potentially positive effects linked to pain. This framework can aid the understanding of why people sometimes seek out, enjoy, and gain rewards from pain as well as pleasure.

## 1 Introduction

Some people dream of a pain-free life. Some – very few – of us are born without the ability to feel pain. They dream instead of a long life. Knowing intimately how useful pain is for survival, people with congenital insensitivity to pain depend on information from other senses to avoid bodily harm. Noticing a scorch by the smell of burnt flesh instead of by sensing the noxious heat is a frightening scenario and a compelling illustration of why pain may be a good thing. Being able to feel pain is useful, but can it

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also be beneficial and enhance pleasure? We have argued that pain is best understood by considering its potential benefits in addition to its better-known drawbacks (see Bastian et al. 2014b, for a more detailed discussion).

## 2 Is Pain Always Unpleasant?

The International Association for the Study of Pain (IASP)'s mission is to achieve pain relief for patients throughout the world. This worthy endeavour helps alleviate pain and suffering caused by injury or surgery. Pain researchers and clinicians also strive to prevent and cure chronic pain. The subjective nature of pain is at the core of this work. Feeling pain is the main reason that people seek medical assistance. Conversely, the suffering caused by pain is what motivates researchers and clinicians' efforts to develop new treatments for pain relief. Accordingly, the IASP task force on taxonomy defines pain as:

> "an unpleasant sensory and emotional experience associated with actual or potential tissue damage or described in terms of such damage."

This working definition has been upheld for more than three decades. Its emphasis that the experience of pain can arise in the absence of damage to the body has been of great importance in the pain field. Phantom pain and post-stroke pain are conditions that exemplify this (Flor et al. 2006).

Despite the worth of IASP's definition for work on providing and optimizing pain relief, we believe its insistence that pain is unpleasant may limit its psychological validity. Most of the time potential or actual tissue damage, or experiences described in terms of such damage, are unpleasant, threatening and aversive. Yet the net emotional evaluation of an experience is a result of numerous and complex factors. The pain arising from your muscles can render an experience aversive, as when a headache ruins an otherwise pleasant enough meeting. But pain from the muscles can also tip the scales in a favourable direction, for instance adding meaning ('I'm building new muscles') to an otherwise uninspiring gym session, or by increasing attention to other sensory signals that add to our pleasure. Sometimes people enjoy pain because we are proud of our ability to endure it. Other times we choose to experience pain that is unpleasant at the time, because we believe it will be worth it in the long run. Perhaps we will feel better for it afterwards. Perhaps other people will feel better about us when they find out what we have endured.

The term 'algosity' refers to a specific quality that identifies a sensation as painful rather than just unpleasant (Fields 1999). This view establishes pain and unpleasantness as separate, albeit frequently co-occuring phenomena. A number of other experiences can be unpleasant without being painful, for instance itch and nausea (Craig 2002). Conversely, pain asymbolia is a condition where patients report feeling pain but not unpleasantness or suffering (Berthier et al. 1988). We hold that a range of activities may involve a detectable quality of pain without rendering the overall experience aversive. Other activities that involve pain can confer a range of benefits *despite* being aversive. Note that we fully recognize that painful events are aversive and unpleasant in the vast majority of cases. The close link between pain and bodily harm also ensures that even

those activities that we evaluate as positive may, if they involve pain, become harmful over time. For instance, although there are numerous health benefits associated with pushing oneself beyond the pain threshold during endurance sports, over time these behaviours also increase the risk of injury due to strain (e.g. Verrall et al. 2006).

In considering the various benefits of pain we wish to move beyond a view of pain as *simply* unpleasant. It certainly may be, but it can also be experienced as pleasant, produce pleasant experiences, or motivate us towards pleasant experiences. Pain is often unpleasant, but focusing only on this quality of pain limits our ability to engage with and understand its many benefits.

## 3 Nociception and Pain

When tissue damage occurs, signals of the event are transmitted to the central nervous system through nociceptors. These sensory neurons are situated throughout the skin and other bodily tissues. They encode pain-related properties of sensory events, such as sharpness or burning. However as we have seen, pain can occur in the absence of nociception (Willoch et al. 2000). Nociception and pain are nevertheless tightly linked, and to understand pain we often turn to nociception. However, assuming that pain depends on nociception and vice versa may suffer from circularity, since knowledge of the sensory thresholds for pain or tissue damage may have influenced the initial classification of sensory neurons into nociceptors.

Points of divergence between pain and nociception have generated substantial interest. For instance, the thermal grill illusion can cause pain through a combination of non-noxious heat and cold stimuli (Craig and Bushnell 1994). The popularity of foodstuffs that activate nociceptors in the lips, mouth and throat are also a source of fascination (Rozin 1999), and it is easy to jump to the conclusion that eating a hot curry must be painful. After all, the active ingredient in chilli peppers, capsaicin, activates heat-sensitive nociceptors. Capsaicin can even reduce the threshold of these heat sensors, causing hyperalgesia to temperatures that otherwise do not produce nociception or pain (Petersen and Rowbotham 1999). Do the world's many curry-lovers demonstrate a benign type of masochism (Rozin et al. 2013)?

## 4 Mixed Emotions

How do we determine whether eating a hot curry is painful? Depending on their preferences and tolerance for spicy foods, some people will find it delicious and not painful, others painful to the obliteration of pleasure (Rozin and Schiller 1980). For the 'hard-boiled' chilli-lovers, repeated exposure to capsaicin may have caused tolerance and hypoalgesia by reducing the number of heat-sensitive nociceptors in the mouth area. In other words, they feel no pain because they lack nociceptive receptors sensitive to capsaicin. Another possibility is that the nociceptive signal reaches the brain, but is interpreted as non-threatening and non-painful. This contrasts with the group of people who report finding spicy food painful to eat. For them, the spices induce nociception

which leads to the experience of pain and aversion. Some of them will nevertheless order hot curries again and again, tears running down their cheeks as they persist through their self-inflicted ordeal. Why people deliberately put themselves through painful experiences is discussed below as we review potential benefits of pain.

In general, pain and pleasure are mutually inhibitory. Pain reduces pleasure and reward signals decrease pain (Fields 2006; Leknes and Tracey 2008). But the opposite of pleasure is not pain, it is displeasure, aversion. The mutual inhibition of pain and pleasure does not prevent us from sometimes experiencing both feelings simultaneously. For instance, some people will report finding a hot curry both delicious *and* painful. How can we feel pleasure and pain at the same time? The psychology literature on mixed emotions confirms that people have little difficulty in reporting concurrent positive and negative emotions (e.g. Larsen et al. 2004; Schellenberg et al. 2008; Schimmack 2001, 2005). Further support comes from studies on taste. In line with the popularity of spicing up dishes with irritants such as capsaicin, combining bitter flavours with sweet or savoury foods is common across cultures (McGee 2004). Indeed, in rats bittersweet foods elicit taste reactivity patterns reflecting both bitterness aversion and sweet liking (Berridge and Grill 1983).

Experiencing a mix of positive and negative hedonic reactions to an event does not prevent us from reaching a single decision about how well we like or dislike the experience overall. People regularly choose to buy and eat foods that elicit aversive reactions, much in the same way that rats approach and consume bittersweet chocolate. Essentially, we humans prefer some of our foods a little bitter, a little spicy, a little challenging to the palate. We propose that pain, in manageable quantities, may similarly integrate with other factors to form a whole that is sometimes evaluated, overall, as positive and likeable. Indeed, a bit of pain may enhance the pleasure of other sensory experiences.

## 5 Hot Curries and the Benefits of Pain

Consider the following scenario. You are taken out for dinner and somehow end up being served an exceedingly hot curry. Despite its delicious ingredients and the pleasant aromas tickling your nose you find it horribly painful. The chillies and spices dominate and you are unable to take pleasure in your meal. Below we outline some potential benefits of your curry-induced agony and consider a range of putative mechanisms at play in this situation. Briefly, 1) Reconceptualizing pain from threat to challenge can give you a sense of accomplishment, partly because your choice demonstrates 2) positive qualities such as strength and self-control to ourselves and to others. 3) Because pain is generally aversive, it also represents a possibility for atonement and redemption after a transgression. These positive social effects represent an addition of resources available to meet subsequent threats. 4) Similarly, pain may motivate the accumulation of resources such as social support and calorie-rich foods, which can strengthen our defence systems. 5) Pain enhances attention to signals from the body and may thereby enhance pleasant sensations. 6) Pain's offset

gives rise to relief, which can add a pleasant gloss to pleasures and pains alike. Contrast and relief also contribute to 7) the ability of pain to inhibit other unpleasant experiences, notably itch and pain.

1. ***From painful threat to painful challenge***

   The capsaicin in your curry activates a great number of nociceptors on the lips and in your mouth and throat. This sudden onslaught of nociceptive signalling activates your fight-or-flight system and causes a number of physiological changes (tears running down your face, your pulse increasing). Once the initial feeling that your head is burning up from the inside subsides, you may try another tack. Why not treat the pain as a challenge to be overcome? After all, you know that this curry is not dangerous to eat. What's more, no one is holding a gun to your head. It is up to you whether to continue eating or not. This perception of control can help you to reconceptualise the pain ***from threat to challenge***. Feeling in control reduces the intensity of post-operative pain and has similar analgesic effects in experimental pain studies (e.g. Salomons et al. 2004; Wiech et al. 2006). Reconceptualising pain as a challenge alters its meaning (Moerman and Jonas 2002). The perception that enduring this pain was your own decision may also activate the psychological and reward-related neural mechanisms which make us prefer the options we have chosen in the past (Sharot et al. 2009). In other words, your pain experience may seem better in retrospect. This mechanism may in turn increase the likelihood that you go back for more hot curry in the future.

   Engaging with challenges that can be mastered and overcome is an important component of living a satisfying life. Pain represents a particularly visceral challenge. Consider the notion of running a pain-free marathon. Would you bother? Why not just sit at home and be equally challenged by the television? Would we watch the Tour de France if it were akin to taking a walk in the park? Overcoming challenges in life is not only rewarding for us, but makes good entertainment for others. Pain is often front and centre of these challenges and overcoming pain provides for a sense of accomplishment.

   Most of what we know about pain from experimental studies relates to pain as a challenge and not to pain as a threat. For reasons of safety and ethics, very few experimental studies of pain involve actual tissue damage (Olesen et al. 2012). Participants in pain studies are informed that no real harm will come to them. Why do they volunteer to undergo the pain and discomfort of such studies? Whilst monetary rewards and altruism should not be underestimated as motivations, tackling the challenge of enduring pain is a reason explicitly stated by many volunteers. In the cold-pressor test, participants are asked to keep their hand in ice-cold (1 °C) water for as long as they can or up to a time limit. Franklin and colleagues used this test as a model for nonsuicidal self-injury (NSSI) and found that after pain, self-harmers' level of negative emotion was reduced. Interestingly, the healthy volunteers also felt better after undergoing the pain challenge (Franklin et al. 2010). In other words, having undergone pain made both

patients and controls feel better. This mood-boosting effect of pain may be related to several of the mechanisms discussed below, including relief, contrast and the link between pain and positive personality traits.

2. ***When pain makes you a better person***

At the curry house, you have chosen to persevere through the chilli-laden dish. In this scenario, the others may spur you on and importantly, praise you for your demonstration of strength, self-control and determination (e.g. see Downey 2007). The ***perception of positive personality traits*** in those who stoically endure pain is not limited to others: we also value the opportunity of proving to ourselves that we possess these qualities. As Morris (1991) notes, tolerance of pain breeds a perception that a person is noble and heroic.

In sporting contexts or war, enduring pain highlights bravery and other qualities traditionally associated with the masculine. Enduring pain in child-birth is often linked to feminine qualities. Scientists have found little support for the popular belief that women tolerate more pain than men, however. Indeed, the opposite may be true (Defrin et al. 2009). Belonging to a group known for high pain tolerance is associated with social status.

As pain researchers, we are often asked to compare a study volunteer's pain tolerance to that of others. However, these requests are based on the misconception that people have one consistent pain tolerance level. Studies comparing responses to different pain models find modest or non-existent correlations between modalities, however (Nielsen et al. 2008). If you tolerate heat pain well, this has virtually no bearings on whether you can stand pressure or muscle pain. There is also large within-modality variance in pain tolerance. Your current level of motivation is one important factor, as evidenced perhaps by studies showing that men report less pain when the experimenter is an attractive female (Levine and De Simone 1991). The professional status of the experimenter also affects pain tolerance (Kallai et al. 2004). Your mood (Berna et al. 2010), anxiety levels (Arntz et al. 1994), and attention (McCaul and Malott 1984; Tracey et al. 2002) are other powerful modulators of pain tolerance. As we have reviewed elsewhere, the presence of or even the mere possibility of sensory and abstract pleasures can also help us appear stoical in the face of pain (Leknes and Tracey 2008). For the volunteers asking about their tolerance, this is not a popular answer, however. Pain study volunteers often appear to seek confirmation of their personal virtues as someone who can endure a lot of pain.

Indeed, by persevering through your painfully hot curry you are likely to receive sympathy and respect from others. Your dinner companions may chuckle at your demonstrations of pain (your facial expression, the tears and other observable physiological effects), but they will likely do so in a friendly and supportive way. Indeed, expressing pain often elicits ***empathy*** and ***social support*** from others (e.g. Danziger et al. 2006; Singer et al. 2004). Humans have evolved a distinct and specific facial expression of pain observable from infancy to old age. Even when we attempt to suppress our facial expression of pain, it is easily detectable by observers (Williams 2002), a factor you are probably oblivious to as you try to appear stoical over your curry.

3. ***Paying the price: improvement and atonement***

A tweak to the curry house scenario changes the focus from physical suffering to morality. In this scenario, you have acted in a way that you or your dinner companions find morally or ethically wrong. Whatever it was,

you are now in the wrong. Somewhat surprisingly, the hot curry you have been struggling with may represent your ***redemption***. Transgressions must be paid for, redeemed, at a cost to the person responsible. As illustrated by various religious practices (self-flagellation, mortification of the flesh), pain is the embodiment of atonement (Bastian et al. 2014b).

Whether you eat the curry as self-punishment or to satisfy others, your pain may therefore redeem you. Bastian and colleagues have provided experimental evidence for this notion. Students who had spent ten minutes focusing on a previous immoral act endured the cold-pressor test for longer, and felt better afterwards than students in the non-guilt condition (Bastian et al. 2011). Guilty students who did not endure pain felt more guilt after the task, illustrating the cleansing effect of the painful experience. Importantly, other people also perceive us as less guilty when they know we have endured pain (Gray and Wegner 2010). People appear more guilty before they have paid for their transgressions, and pain is one way of paying the price. Social exclusion or loss of freedom through incarceration are other common ways that can lead to redemption in the eyes of others. Painful rituals are also prevalent within certain religious traditions. Overall, the level of pain or suffering necessary for atonement appears to hinge on the gravity of the transgression. Eating a painfully hot curry may help your friends forget that you were late for the restaurant – again! But if you have stolen, lied and cheated, even intense self-flagellation might not bring you forgiveness.

A recent experimental study highlights another way in which pain can be seen as a payment. People learn from an early age that some good things in life can only be achieved through large or long-lasting efforts. Processes requiring painful efforts are typically the most demanding, and undergoing these exertions is thus associated with greater subsequent benefits. In the study, participants performed an effortful motor task. A subgroup were led to believe that the ensuing pain was a sign of achievement. Specifically, the pain was an indication that they were building up muscle tissue (Benedetti et al. 2013). The task thus closely mimicked the role pain can play in sports or fitness. Benedetti and coauthors concluded that understanding pain in this way reduced the aversiveness of the experience through co-activation of the opioid and cannabinoid systems of the brain. The effects of pain on motivation and perception of task performance were not assessed, however. We speculate that undergoing painful efforts to obtain a future reward, such as bigger or stronger muscles, may increase the perception of moving closer to that goal. In other words, the painful exercise is interpreted as more effective in building muscle tissue than non-painful exercise. You have paid the price – in pain – and therefore the results should appear. This could become a self-fulfilling prophecy by enhancing motivation to expend effort, and also perhaps by activating beneficial placebo effects (Benedetti et al. 2007; Ellingsen et al. 2013). Many medical treatments involve pain and discomfort, and these produce larger placebo benefits than 'milder' non-painful treatments. For instance, placebo injections reduce pain more effectively than placebo pills (Moerman and Jonas 2002).

4. ***Building up resources: social motivation and self-indulgence***

To recap, revealing your pain to others can elicit empathy, social support and reduce their perception of your guilt. However these benefits must be weighed against a potential loss of social status. If you cannot tolerate the pain caused by a spicy curry, it could be a sign that you are lacking in self-control and determination. To compensate for the potential sign of weakness, you may well crack a lot of jokes about your suffering and exert yourself to be liked.

Indeed, pain may encourage us to ***seek out social resources*** in the form of social bonds. From infancy, humans learn that expressing pain leads to social support, and that social support is necessary for survival. In evolutionary terms, social support is a resource. Building up resources enables you to cope with future painful threats or challenges. Robust evidence suggests that social support helps us cope with pain (Dunbar et al. 2011; Eisenberger et al. 2011; Panksepp 2005).

Pain can also promote the stocking up of another type of resource: energy. When you have persisted through the ordeal of the main course curry, chances are you'll order a hefty dessert. The feeling that you have suffered through your curry for no good reason could lead you to ***indulge yourself*** with the double banana-split with ice-cream, whipped cream, chocolate sauce and a cherry on top. In other words, the price you paid – in pain – is what entitles you to a subsequent reward. Bastian and colleagues recently demonstrated this effect empirically. Across two experiments, participants were more likely to choose to eat sweets and chocolates after they had endured pain. The effect was stronger when the pain was perceived to be unfair (Bastian et al. 2012). If enduring pain could be seen as paying a price for a past misdeed, people were unlikely to self-indulge. But when the pain appeared unjustified, it was treated instead as a reason to seek short-term gratification.

As with the social bonding, this mechanism promotes the accumulation of resources which can be used to cope with future threats and pains. In contrast with the social bonds, however, the benefits of self-indulgence are usually of short duration. Over time, indulging in guilty pleasures due to unfair pain may cause numerous problems for chronic pain patients, such as obesity and substance abuse. A similar mechanism likely underpins the highly problematic inactivity associated with persistent pain. Taking a breather on the sofa is a self-indulgence which, if repeated often, may form an integral part of the negative cycle of inactivity, social isolation and negative emotionality known to exacerbate chronic pain (Janke and Kozak 2012; Berna et al. 2010; Flor 2007). In the short term, however, pain-related self-indulgence can of course be the cause of substantial sensory pleasures. The mechanisms discussed below similarly tie pain in with short-term pleasure.

5. ***Attention enhancing sensation***

An interesting effect of eating very spicy food is that causes an automatic increase in ***attention*** to sensory information from your lips and mouth. Pain's ability to attract attention can be a disadvantage and distract us from the tasks at hand (Crombez et al. 1996). But the enhanced attention can also serve to enhance pleasurable sensations by increasing the intensity and processing of other sensory signals, such the taste and odours of your curry. A recent experimental study showed that after enduring pain (cold pressor test), participants experienced tastes

as more intense and more pleasurable (Bastian et al. 2014a). Participants were also better at distinguishing between similar flavours. Another study reported enhanced taste perception in patients with chronic back pain (Small and Apkarian 2006). These findings support the hypothesis that pain's attention-grabbing quality can also enhance the sensual pleasures of eating food. However, as with most good things, over time these benefits may lead to over-indulgence. Indeed, chronic pain patients have a higher risk of obesity (Janke and Kozak 2012). On the other hand, the world's many lean curry-lovers provide some evidence that repeated self-administration of potentially painful foods, can also provide a long-lasting source of sensory pleasure. Other mechanisms of pain-related pleasure are contrast and relief, the basis for the final benefits of pain discussed here.

6. ***In the world of the blind, the one-eyed man is king***

Whilst short-lasting, the sip of water you had after the initial onslaught of the curry did for a moment provide ***relief***, briefly removing the intense burning in your mouth and throat. For that fleeting moment, it may have been the best drink of water you ever had. Now, you may argue that this fleeting pleasantness was completely outweighed by the curry-induced pain. Moreover, your pain likely returned with greater strength after your attempt for rescue. The relevant mechanism here is ***contrast*** (Cabanac 1979; Seymour and McClure 2008).

Pain affords an effective contrast to many non-painful experiences, which can appear relatively pleasant or rewarding if they occur after pain has ended. For instance, fruit flies approached odours associated with pain offset (the end of a painful event) even when these odours were initially mildly aversive (Tanimoto et al. 2004). Similar effects have been observed in rats (Smith and Buchanan 1954) and humans (Leknes et al. 2008). The contrast afforded by pain and other aversive experiences is closely associated with the subjective experience of relief. Although introspection suggests to many people that relief and pleasure are easily dissociated, most primary rewards are intensified by relief. Food and drink taste better when providing relief from hunger or thirst (Cabanac 1979; Kringelbach 2004). And where would the pleasure in going to bed at night be if we were not so tired, our muscles weary and aching? Although not commonly considered a basic emotion, relief is nevertheless recognisable from both facial expressions and tone of voice (Ethofer et al. 2009; Krumhuber and Scherer 2011).

In studies of pain, relief arises from pain offset, reduction in ongoing pain or even from the knowledge that pain has been avoided (Andreatta et al. 2010; Grill and Coghill 2002; Seymour et al. 2005). Relief hinges on the real or imagined existence of pain, and the pleasantness of relief is closely related to the aversiveness of the event that has been reduced or avoided (Leknes et al. 2008). For instance, pessimism increases the pleasantness of avoiding pain (Leknes et al. 2011). In other words, feeling bad about pain is what causes relief of pain to be pleasurable. Without pain, Tanimoto's fruit flies would still find those odours mildly aversive, and your drink of water after that mouthful of hot curry would not provide such intense and pleasant relief.

Relief's reliance on pain and suffering sets this phenomenon apart from other pleasures. Optimists, who report the least pleasantness from learning that they have safely avoided an impending pain stimulus, otherwise appear to be well-equipped for enjoying what life has to offer. Optimism is associated with resilience to

negative feelings, good health and even longevity (Carver and Scheier 2005; Carver et al. 2010). Nevertheless, they may miss out on the pleasure of finding that events did not turn out as painful as anticipated. Despite its reliance on initial pain and aversion, relief is classified as a positive emotion (Ethofer et al. 2009; Krumhuber and Scherer 2011).

The contrast between that brief respite and the pain's recurrence as you swallow your water is a painful reminder that contrast effects are not always beneficial. Nevertheless, relief can be a potent source of pleasure. In a recent study, we found that relief from avoiding very intense pain was able to render pleasant the experience of moderate heat pain (Leknes et al. 2013). The positive feelings elicited by safety from intense pain caused a 'hedonic flip' of the otherwise aversive experience of moderately painful heat. Participants felt the heat as painful but nevertheless rated the overall experience as pleasant.

7. ***Fighting evil with evil***

To obtain this particular benefit of pain, you need more pain. Let us say that you have a bad back which can get painful after some time in a restaurant chair. A clear benefit of your hot curry experience is that it may well help you forget your back altogether. Given the excruciating, burning sensation the curry has incited in your mouth this effect may not feel like much of a compensation. But for many sufferers of persistent pain, the temporary ***respite from other pain*** offered by capsaicin or other irritants represents a valued coping strategy (Mason et al. 2004). Pain's ability to reduce other pain is sometimes referred to as counter-irritation or diffuse descending noxious control (DNIC) and is known from numerous studies in rats (e.g. Gear et al. 1999) and humans (e.g. Piche et al. 2009; Wilder-Smith et al. 2004). Notably, pain can also inhibit other aversive and attention-grabbing experiences. For instance, exzema sufferers sometimes seek out painful activities because the pain alleviates their itch (Launer 2004). Indeed, that time when you scratched your mosquito bite too hard, you may well have succumbed to a subconscious drive for pain-induced relief of itch. As we have seen, relief from unpleasant experiences can be highly pleasurable. Getting rid of itch, pain or nausea quickly enough that you sense the contrast (Solomon and Corbit 1974), can leave you delighted with your normal senses. A familiar example is that great feeling of a clear head and breathing through your nose after a head-cold. And if you think back, digging your nails into that mosquito bite did feel rather marvelous, did it not?

## 6 The Benefits of Pain

In most situations, pain's benefits are unlikely to outweigh the concurrent suffering. Of course, one or more of the above mechanisms could certainly contribute to a hedonic flip from aversive to pleasant pain, as appears to occur for at least some novices at spicy foods. Similarly, longer-term processes in which we reconceptualise pain from threat to challenge or find pain meaningful in other ways, could leave us grateful for past pain. But pain's attention-grabbing ability and its close association with threat, tissue damage and negative emotion will generally ensure an uneven playing field. Of course your

mother's comforting hand on your arm can feel good, but will her kindness outweigh the agony of a recently broken ankle?

Many of the potential benefits we have reviewed are of short duration and may indeed contribute to suffering in the long run. The sympathy and support received at the onset of a painful condition can dry out. Instead of appearing stoical, you may come to be seen as someone who complains a lot (Werner et al. 2004). Non-suicidal self-injury is another example where short-term benefits such as relief from emotional distress or numbness, may contribute to repeated injuries and pathology over time (Franklin et al. 2010). Nevertheless, we believe that it is important to consider pain in the wider sense, as outlined here and by Bastian et al. (2014b). The mission of psychology and philosophy, after all, is broader than that of the International Association for the Study of Pain. Our mission is to understand the human mind, with all its idiosyncracies and paradoxes. This includes the possibility that people may seek out, enjoy, and gain rewards from pain as well as pleasure.

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## References

Amy Janke, E., and A.T. Kozak. 2012. "The more pain I have, the more I want to eat": Obesity in the context of chronic pain. [Research Support, U.S. Gov't, Non-P.H.S.]. *Obesity (Silver Spring)* 20(10): 2027–2034.

Andreatta, M., A. Muhlberger, A. Yarali, B. Gerber, and P. Pauli. 2010. A rift between implicit and explicit conditioned valence in human pain relief learning. *Proceedings of the Biological Sciences* 277(1692): 2411–2416.

Arntz, A., L. Dreessen, and P. De Jong. 1994. The influence of anxiety on pain: Attentional and attributional mediators. *Pain* 56(3): 307–314.

Bastian, B., J. Jetten, and F. Fasoli. 2011. Cleansing the soul by hurting the flesh: The guilt-reducing effect of pain. *Psychological Science* 22(3): 334–335.

Bastian, B., J. Jetten, and E. Stewart. 2012. Physical pain and guilty pleasures. *Social Psychological and Personality Science* 4(2): 215–219.

Bastian, B., J. Jetten, and M.J. Hornsey. 2014a. Gustatory pleasure and pain. The offset of acute physical pain enhances responsiveness to taste. *Appetite* 72: 150–155.

Bastian, B., Jetten, J., Hornsey, M, and Leknes, Siri. 2014b. The positive consequences of pain: A biopsychosocial approach. *Journal of Personality and Social Psychology*. In press.

Benedetti, F., A. Pollo, and L. Colloca. 2007. Opioid-mediated placebo responses boost pain endurance and physical performance: Is it doping in sport competitions? *Journal of Neuroscience* 27(44): 11934–11939.

Benedetti, F., W. Thoen, C. Blanchard, S. Vighetti, and C. Arduino. 2013. Pain as a reward: Changing the meaning of pain from negative to positive co-activates opioid and cannabinoid systems. *Pain* 154(3): 361–367.

Berna, C., S. Leknes, E.A. Holmes, R.R. Edwards, G.M. Goodwin, and I. Tracey. 2010. Induction of depressed mood disrupts emotion regulation neurocircuitry and enhances pain unpleasantness. *Biological Psychiatry* 67(11): 1083–1090.

Berridge, K.C., and H.J. Grill. 1983. Alternating ingestive and aversive consummatory responses suggest a two-dimensional analysis of palatability in rats. *Behavioral Neuroscience* 97(4): 563–573.

Berthier, M., S. Starkstein, and R. Leiguarda. 1988. Asymbolia for pain: A sensory-limbic disconnection syndrome. *Annals of Neurology* 24(1): 41–49.

Cabanac, M. 1979. Sensory pleasure. *Quarterly Review of Biology* 54(1): 1–29.

Carver, C.S., and M.F. Scheier. 2005. Optimism. In *Handbook of positive psychology*, ed. C.R. Snyder and S.J. Lopez, 231–243. New York: Oxford University Press.

Carver, C.S., M.F. Scheier, and S.C. Segerstrom. 2010. Optimism. *Clinical Psychology Review* 30(7): 879–889.

Craig, A.D. 2002. How do you feel? Interoception: The sense of the physiological condition of the body. *Nature Reviews Neuroscience* 3(8): 655–666.

Craig, A.D., and M.C. Bushnell. 1994. The thermal grill illusion: Unmasking the burn of cold pain. [Research Support, U.S. Gov't, P.H.S.]. *Science* 265(5169): 252–255.

Crombez, G., C. Eccleston, F. Baeyens, and P. Eelen. 1996. The disruptive nature of pain: An experimental investigation. *Behaviour Research and Therapy* 34(11–12): 911–918.

Danziger, N., K.M. Prkachin, and J.C. Willer. 2006. Is pain the price of empathy? The perception of others' pain in patients with congenital insensitivity to pain. *Brain* 129(Pt 9): 2494–2507.

Defrin, R., L. Shramm, and I. Eli. 2009. Gender role expectations of pain is associated with pain tolerance limit but not with pain threshold. [Comparative Study]. *Pain* 145(1–2): 230–236.

Downey, G. 2007. Producing pain: Techniques and technologies in no-holds-barred fighting. *Social Studies of Science* 37(2): 201–226.

Dunbar, R.I.M., R. Baron, A. Frangou, E. Pearce, E.J.C. van Leeuwen, J. Stow, and M. van Vugt. 2011. Social laughter is correlated with an elevated pain threshold. *Proceedings of the Royal Society B: Biological Sciences* 279(1731): 1161–1167.

Eisenberger, N.I., S.L. Master, T.K. Inagaki, S.E. Taylor, D. Shirinyan, M.D. Lieberman, and B.D. Naliboff. 2011. Attachment figures activate a safety signal-related neural region and reduce pain experience. *Proceedings of the National Academy of Sciences of the United States of America* 108(28): 11721–11726.

Ellingsen, D.-M., J. Wessberg, M. Eikemo, J. Liljencrantz, T. Endestad, H. Olausson, and S. Leknes. 2013. Placebo improves pleasure and pain through opposite modulation of sensory processing. *Proceedings of the National Academy of Sciences* 110(44): 17993–17998.

Ethofer, T., D. Van De Ville, K. Scherer, and P. Vuilleumier. 2009. Decoding of emotional information in voice-sensitive cortices. [Research Support, Non-U.S. Gov't]. *Current Biology* 19(12): 1028–1033.

Fields, H.L. 1999. Pain: An unpleasant topic. *Pain Supplement* 6: S61–S69.

Fields, H.L. 2006. A motivation-decision model of pain: The role of opioids. In *Proceedings of the 11th world congress on pain*, ed. H. Flor, E. Kalso, and J.O. Dostrovsky, 449–459. Seattle: IASP Press.

Flor, H. 2007. Operant treatment of chronic pain. In *Encyclopedia of pain*, ed. R.F. Schmidt and W.D. Willis. Berlin: Springer-Verlag.

Flor, H., L. Nikolajsen, and T. Staehelin Jensen. 2006. Phantom limb pain: A case of maladaptive cns plasticity? [Review]. *Nature Reviews. Neuroscience* 7(11): 873–881.

Franklin, J.C., E.T. Hessel, R.V. Aaron, M.S. Arthur, N. Heilbron, and M.J. Prinstein. 2010. The functions of nonsuicidal self-injury: Support for cognitive-affective regulation and opponent processes from a novel psychophysiological paradigm. *Journal of Abnormal Psychology* 119(4): 850–862.

Gear, R.W., K.O. Aley, and J.D. Levine. 1999. Pain-induced analgesia mediated by mesolimbic reward circuits. *Journal of Neuroscience* 19(16): 7175–7181.

Gray, K., and D.M. Wegner. 2010. Torture and judgments of guilt. *Journal of Experimental Social Psychology* 46(1): 233–235.

Grill, J.D., and R.C. Coghill. 2002. Transient analgesia evoked by noxious stimulus offset. *Journal of Neurophysiology* 87(4): 2205–2208.

Kallai, I., A. Barke, and U. Voss. 2004. The effects of experimenter characteristics on pain reports in women and men. [Comparative Study]. *Pain* 112(1–2): 142–147.

Kringelbach, M.L. 2004. Food for thought: Hedonic experience beyond homeostasis in the human brain. *Neuroscience* 126(4): 807–819.

Krumhuber, E.G., and K.R. Scherer. 2011. Affect bursts: Dynamic patterns of facial expression. [Research Support, Non-U.S. Gov't]. *Emotion* 11(4): 825–841.

Larsen, J.T., A. Peter McGraw, B.A. Mellers, and J.T. Cacioppo. 2004. The agony of victory and thrill of defeat. *Psychological Science* 15(5): 325–330.

Launer, J. 2004. The itch. *QJM* 97(6): 383–384.

Leknes, S., and I. Tracey. 2008. A common neurobiology for pain and pleasure. *Nature Reviews Neuroscience* 9(4): 314–320.

Leknes, S., J.C.W. Brooks, K. Wiech, and I. Tracey. 2008. Pain relief as an opponent process: A psychophysical investigation. *European Journal of Neuroscience* 28(4): 794–801.

Leknes, S., M. Lee, C. Berna, J. Andersson, and I. Tracey. 2011. Relief as a reward: Hedonic and neural responses to safety from pain. *PLoS ONE* 6(4): e17870.

Leknes, S., C. Berna, M.C. Lee, G.D. Snyder, G. Biele, and I. Tracey. 2013. The importance of context: When relative relief renders pain pleasant. *Pain* 154(3): 402–410.

Levine, F.M., and L.L. De Simone. 1991. The effects of experimenter gender on pain report in male and female subjects. *Pain* 44(1): 69–72.

Mason, L., R.A. Moore, S. Derry, J.E. Edwards, and H.J. McQuay. 2004. Systematic review of topical capsaicin for the treatment of chronic pain. [Meta-Analysis]. *BMJ (Clinical Research Ed.)* 328(7446): 991.

McCaul, K.D., and J.M. Malott. 1984. Distraction and coping with pain. *Psychological Bulletin* 95(3): 516–533.

McGee, Harold. 2004. *On food and cooking: The science and lore of the kitchen* (Rev Upd edition ed.): Scribner.

Moerman, D.E., and W.B. Jonas. 2002. Deconstructing the placebo effect and finding the meaning response. *Annals of Internal Medicine* 136(6): 471–476.

Morris, D.B. 1991. *The culture of pain*. Berkeley: University of California Press.

Nielsen, C.S., A. Stubhaug, D.D. Price, O. Vassend, N. Czajkowski, and J.R. Harris. 2008. Individual differences in pain sensitivity: Genetic and environmental contributions. *Pain* 136(1–2): 21–29.

Olesen, A.E., T. Andresen, C. Staahl, and A.M. Drewes. 2012. Human experimental pain models for assessing the therapeutic efficacy of analgesic drugs. *Pharmacological Reviews* 64(3): 722–779.

Panksepp, J. 2005. Social support and pain. *Journal of Cancer Pain & Symptom Palliation* 1(1): 59–65.

Petersen, K.L., and M.C. Rowbotham. 1999. A new human experimental pain model: The heat/capsaicin sensitization model. *NeuroReport* 10: 1511–1516.

Piche, M., M. Arsenault, and P. Rainville. 2009. Cerebral and cerebrospinal processes underlying counterirritation analgesia. *Journal of Neuroscience* 29(45): 14236–14246.

Rozin, P. 1999. Preadaptation and the puzzles and properties of pleasure. In *Well-being: The foundations of hedonic psychology*, ed. D. Kahneman, E. Diener, and N. Schwartz, 109–133. New York: Russell Sage Foundation.

Rozin, P., and D. Schiller. 1980. The nature and acquisition of a preference for chili pepper by humans. *Motivation and Emotion* 4(1): 77–101.

Rozin, P., L. Guillot, K. Fincher, A. Rozin, and E. Tsukayama. 2013. Glad to be sad, and other examples of benign masochism. *Judgement and Decision Making* 8(4): 439–447.

Salomons, T.V., T. Johnstone, M.-M. Backonja, and R.J. Davidson. 2004. Perceived controllability modulates the neural response to pain. *Journal of Neuroscience* 24(32): 7199–7203.

Schellenberg, E.G., P.G. Hunter, and U. Schimmack. 2008. Mixed affective responses to music with conflicting cues. *Cognition & Emotion* 22(2): 327–352.

Schimmack, U. 2001. Pleasure, displeasure, and mixed feelings: Are semantic opposites mutually exclusive? *Cognition & Emotion* 15(1): 81–97.

Schimmack, U. 2005. Response latencies of pleasure and displeasure ratings: Further evidence for mixed feelings. *Cognition & Emotion* 19(5): 671–691.

Seymour, B., and S.M. McClure. 2008. Anchors, scales and the relative coding of value in the brain. *Current Opinion in Neurobiology* 18(2): 173–178.

Seymour, B., J.P. O'Doherty, M. Koltzenburg, K. Wiech, R. Frackowiak, K. Friston, and R. Dolan. 2005. Opponent appetitive-aversive neural processes underlie predictive learning of pain relief. *Nature Neuroscience* 8(9): 1234–1240. doi:10.1038/nn1527.

Sharot, T., B. De Martino, and R.J. Dolan. 2009. How choice reveals and shapes expected hedonic outcome. *Journal of Neuroscience* 29(12): 3760–3765.

Singer, T., B. Seymour, J. O'Doherty, H. Kaube, R.J. Dolan, and C.D. Frith. 2004. Empathy for pain involves the affective but not sensory components of pain. *Science* 303(5661): 1157–1162.

Small, D.M., and A.V. Apkarian. 2006. Increased taste intensity perception exhibited by patients with chronic back pain. *Pain* 120(1–2): 124–130.

Smith, M.P., and G. Buchanan. 1954. Acquisition of secondary reward by cues associated with shock reduction. *Journal of Experimental Psychology* 48(2): 123–126.

Solomon, R.L., and J.D. Corbit. 1974. An opponent-process theory of motivation: I. Temporal dynamics of affect. *Psychological Review* 81(2): 119–145.

Tanimoto, H., M. Heisenberg, and B. Gerber. 2004. Experimental psychology: Event timing turns punishment to reward. *Nature* 430(7003): 983. doi:10.1038/430983a.

Tracey, I., A. Ploghaus, J.S. Gati, S. Clare, S. Smith, R.S. Menon, and P.M. Matthews. 2002. Imaging attentional modulation of pain in the periaqueductal gray in humans. *Journal of Neuroscience* 22(7): 2748–2752.

Verrall, G.M., Y. Kalairajah, J.P. Slavotinek, and A.J. Spriggins. 2006. Assessment of player performance following return to sport after hamstring muscle strain injury. *Journal of Science and Medicine in Sport* 9(1–2): 87–90.

Werner, A., L.W. Isaksen, and K. Malterud. 2004. 'I am not the kind of woman who complains of everything': Illness stories on self and shame in women with chronic pain. *Social Science and Medicine* 59(5): 1035–1045.

Wiech, K., R. Kalisch, N. Weiskopf, B. Pleger, K.E. Stephan, and R.J. Dolan. 2006. Anterolateral prefrontal cortex mediates the analgesic effect of expected and perceived control over pain. *Journal of Neuroscience* 26(44): 11501–11509.

Wilder-Smith, C.H., D. Schindler, K. Lovblad, S.M. Redmond, and A. Nirkko. 2004. Brain functional magnetic resonance imaging of rectal pain and activation of endogenous inhibitory mechanisms in irritable bowel syndrome patient subgroups and healthy controls. *Gut* 53(11): 1595–1601.

Williams, A.C. 2002. Facial expression of pain: An evolutionary account. [Review]. *Behavioral and Brain Sciences* 25(4): 439–455. discussion 455–488.

Willoch, F., G. Rosen, T.R. Tolle, I. Oye, H.J. Wester, N. Berner, and P. Bartenstein. 2000. Phantom limb pain in the human brain: Unraveling neural circuitries of phantom limb sensations using positron emission tomography. [Research Support, Non-U.S. Gov't]. *Annals of Neurology* 48(6): 842–849.