

# The neurological mechanisms of mindfulness meditation

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### Introduction

Mindfulness meditation is the practice of 'inner listening', concentrating one's attention on the present moment and experiences without judgement. Meditation is an ancient practice that dates back to approximately 5,000 BCE. And yet, only recently has its therapeutic effects been introduced to western medicine. In recent years, meditation has been recommended to individuals suffering from chronic pain, as well as those struggling with mental disorders such as anxiety and depression. Often chronic pain sufferers are diagnosed with comorbid stress and depression. These comorbidities lead to more difficulties for patients, exasperating the pain they experience and decreasing overall quality of life. According to the National Health Interview Survey, approximately 20.4 percent of the U.S. adult population suffered from chronic pain in 2016<sup>1</sup>. In the 4-year period 2005–2008 5.7 percent of the U.S. adult population were using opioids to treat pain<sup>2</sup>. This suggests a large quantity of chronic pain sufferers are currently relying on prescription opioids to help manage their condition. However, opioids are highly addictive and when taken for long periods of time can lead to dependence. Amongst patients with chronic noncancer pain who were prescribed opioids, addiction rates ranged from 3.2 to 18.9%<sup>3</sup>. Because of opioids addictive nature it is important that we begin to look for alternative ways of managing chronic pain that won't cause patients to rely on medication for relief. Mindfulness meditation has been shown to have analgesic and stress reducing effects but there is still a large amount of skepticism towards the practice's efficacy<sup>4</sup>. This review will summarize the proposed neurological mechanisms of mindfulness meditation, its analgesic effects, and methods of stress reduction.

## **Analgesic effects of mindfulness meditation**

One criticism towards mindfulness meditations therapeutic usage is whether its practice employs unique mechanisms of providing pain relief or if its results are merely a placebo effect. Research utilizing fMRI techniques compared functional activation of brain regions when subjects underwent noxious stimuli produced by a TSA-II device, a computer-controlled device capable of generating and documenting response to repeatable thermal stimuli, paired with either mindfulness meditation, sham mindfulness meditation, or placebo<sup>5</sup>. In the group who practiced mindfulness meditation there was a significant decrease in neural activation in brain regions crucially involved in the facilitation and modulation of nociceptive information. Instead, the mindfulness meditation group displayed greater activation in sensory processing regions as well as its own unique cognitive reappraisal processes <sup>5</sup>. Cognitive reappraisal is the reinterpreting of a stimuli or a situation. Altering the interpretation of stimuli can be achieved through an array of different neurological processes. The neurological processes employed by mindfulness meditation were found to be novel. These findings suggest that the mechanisms employed by mindfulness meditation to provide pain relief are different than those of placebo. In individuals practicing mindfulness meditation while receiving noxious stimuli, greater activation was seen in the anterior cingulate cortex and anterior insula, two brain regions associated with the cognitive regulation of processing pain <sup>6</sup>. There is a significant correlation between pain reduction and activation of the orbitofrontal cortex <sup>6</sup>. It has been proposed that meditation employs a limbic

gating mechanism, which modifies interactions between afferent input and higher order brain regions <sup>6</sup>. These modifications are supported by an inactivation of thalamic brain regions <sup>6</sup>. Cognitive reappraisal processes induced through mindfulness meditation are thought to allow for contextual evaluation of sensory events, altering an individual's subjective experience of pain <sup>7</sup>. A study utilizing naloxone, an endogenous opioid blocker, found a significant reduction in mindfulness meditations analgesic effects compared to those injected with saline <sup>8</sup>. This significance suggests mindfulness meditation employs a mechanism of modulating pain through the release of endogenous opioids, specifically in more experienced meditators <sup>8</sup>. In less experienced meditators it is thought that the influence of placebo was stronger, and that with time and practice opioid release was more persistent against psychological influences <sup>8</sup>.

# Mechanisms of stress reduction with mindfulness meditation

Mindfulness meditation is often prescribed to help reduce stress and relieve anxiety. Research investigating the neurological mechanisms of mindfulness meditation related anxiety relief found increased activity in the anterior cingulate cortex, ventromedial prefrontal cortex, and the anterior insula <sup>9</sup>. The amygdala is another brain region of interest, that may attribute to mindfulness meditations stress-relieving effects. One study found that individuals who did eight weeks of mindfulness meditation training had decreased activity in the right amygdala, while those who completed compassion meditation had an increase in activity in the right amygdala compared to baseline activity <sup>10</sup>. Unlike mindfulness meditation, compassion meditation involves the repetition of phrases aiming to move from a judgmental mindset towards a more compassionate state. These differences suggest the changes to resting state of the amygdala is altered via mindfulness meditation. The effect was a decrease in right amygdala-subgenual anterior cingulate cortex (sgACC) activity when under stress <sup>11</sup>. Previous studies found bilateral amygdala-sgACC activity is associated with greater perceived stress <sup>11</sup>. These findings suggest the amygdala-sgACC pathway as a proposed mechanism of stress relief via meditation.

# Mindfulness meditation: clinical applications and looking towards the future

Mindfulness meditation is a promising treatment for individuals suffering from chronic pain and comorbid stress/anxiety. There have been several proposed mechanisms to explain mindfulness meditations analgesic effects such as higher activation in brain regions responsible for cognitive reappraisal processes as well as the release of endogenous opioids. It is thought that mindfulness meditation relieves anxiety through the amygdala-subgenual anterior cingulate cortex pathway. However, the literature varies in whether the activity of the right amygdalasgACC is upregulated or downregulated during meditation. Future studies should investigate the pathway activated by mindfulness meditation to release endogenous opioids and why it may differ between more experienced meditators and inexperienced individuals. Additional research should be conducted comparing the analgesic effects of actively practicing mindfulness meditation in the presence of noxious stimuli as opposed to the effects of a long-term practice. This may provide more insight as to whether or not the neural mechanisms have a lasting effect and can potentially relieve pain without an individual continually meditating. Another pitfall of these studies is the small sample size, future research should work towards increasing the number of participants for more accurate results. The practice of mindfulness meditation should continue to be promoted to chronic pain and anxiety sufferers. It's an attainable skill that is free and can be self-lead making it accessible to the general population with promising results.

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