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Can mindfulness alter pain sensitivity?

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Synopsis

Preface

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1 | Background

1.1 Pain

Pain is defined, by the International Association for the Study of Pain (IASP), as an unpleasant sensory and emotional experience associated with actual or potential tissue damage [**(Marsky and Bogduk, 1994**]. Pain is a sudden or slow onset of any intensity from mild to severe pain [1] and can categorized based on the pain experience as acute, chronic and intermittent pain [2]. Acute pain is anticipated or predictable, while chronic pain is not anticipated or predictable. Chronic pain has a duration greater than three months with a constant or recurring of pain [1].

Pain is a worldwide problem and affects all populations regardless of gender, age, income, ethnicity or geography, but the distribution across the globe differs[2]. The prevalence and incidence is high despite the complexity of quantifying pain[2]. It is estimated that 20% of the world's populations adults suffer from pain and each year 10 % is diagnosed with chronic pain [2].

The frequently causes of pain are operations, cancer, osteoand rheumatoid arthritis, injuries and spinal cord problems [2]. Furthermore, pain can causes to different sequelae, such as depression, inability to work, limit social relationships and suicidal thoughts[2].

People with chronic pain often complain of cognitive problems which interfere with their daily functions [**Geisser2018**]. Additionally, it is indicated that among people with chronic pain there is a consistent evidence for disturbances in attentional capacity, processing speed, and psychomotor speed [**Geisser2018**]. However, the relationship between pain and cognitive problems is unknown [**Geisser2018**].

1.1.1 Types of pain

Pain can be divided into nociceptor pain and neuropathic pain [3]. Nociceptor pain can be classify attending to the location of pain as somatic pain or visceral pain. Somatic pain occurs when nociceptors in skin, muscles, skeleton, joints, or connective tissues are activated. Visceral pain, is defined as pain that results from the activation of nociceptors in the thoracic, pelvic, or abdominal viscera. Unlike somatic pain, visceral pain is harder to localize within the body. On the other hand,neuropathic pain is caused by a primary lesion or dysfunction of the Peripheral Nervous System (PNS) or Central Nervous System (CNS). The main difference from nociceptor pain is that neuropathic pain has an absence of continuous nociceptive inputs [**neuropathic pain**].

Nociceptor pain

Nociceptors are free nerve endings and have a high threshold for mechanical, chemical or thermal stimulation [3]. There are two types of nociceptors $\alpha\delta$ and C fibers. $A\delta$ 2-5μm, myelinated nerve cells, which produce fast well localized sharp pain [3]. The distribution of these fibers are in the body surface, muscles and joints. C fibers, <2μm, unmyelinated nerve cells, and produce slow and poorly localized burning and throbbing pain [3]. The distribution of this fiber type is in most tissues [3]. When a noxious stimulation occurs, the nociceptors will be activated and propagate the pain information to the spinal cord via dorsal horn, as illustrated on figure 1.1 [4]. The second order neuron is activated by the release of neurotransmitters from the nociceptor. The second order neuron receive these information and cross over to the opposite side of the spinal cord and brings the information towards the brain via the lateral spinothalamic tract. This information will be transmitted by releasing neurotransmitters to the third order neuron in the thalamus. The third order neuron localizes and discriminates the pain in the brain, illustrated as a red line on figure 1.1, but reverse from where the pain actually had occured. Perception of pain on the right side of the body is processed on the left side of the brain and vice versa [4].

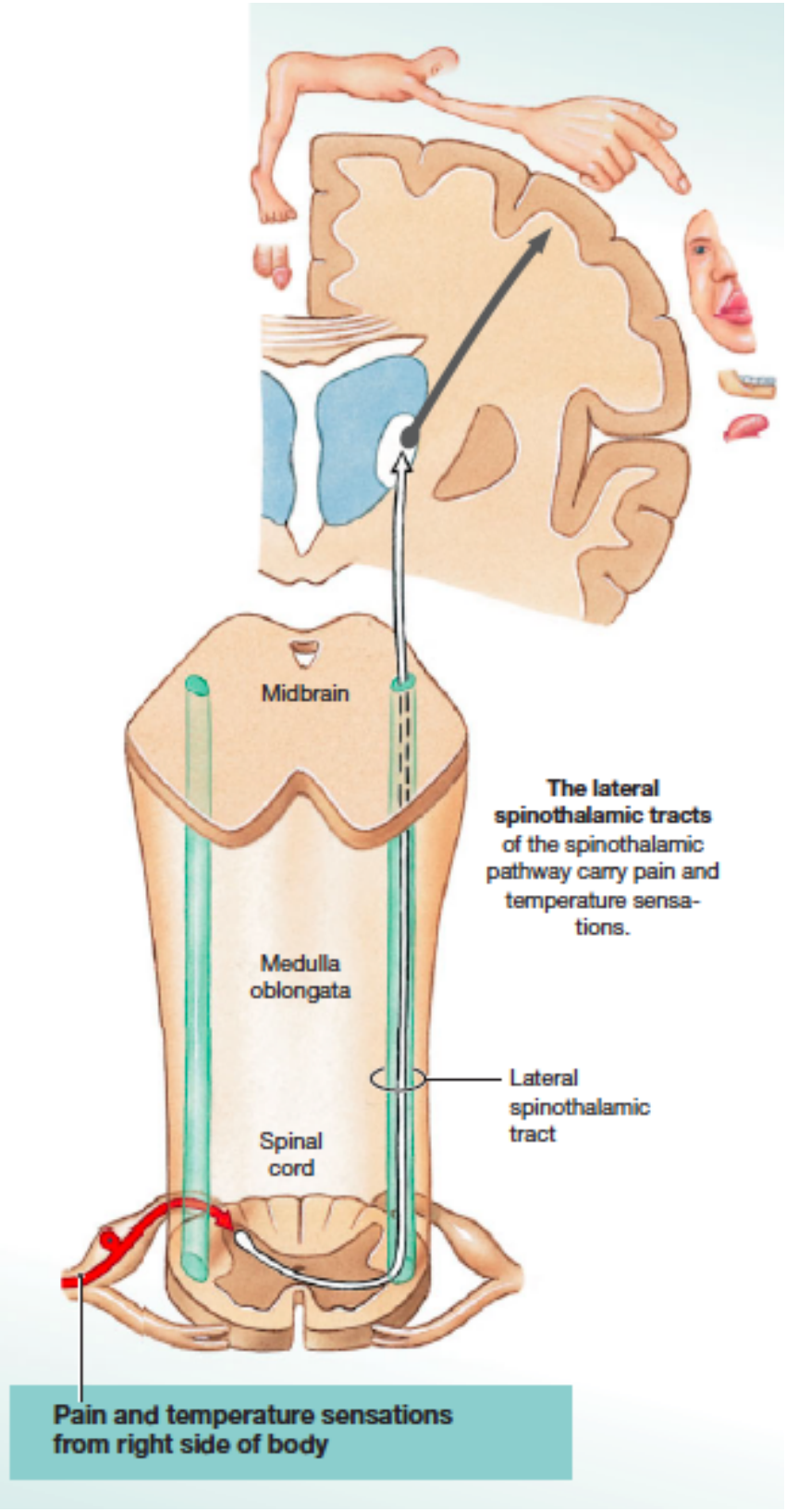

Figure 1.1: Spinothalamic pathway. Modified [4]

Pain is modulated by the descending pathways, where the Periaqueductal Grey (PAG) and the Nucleus Raphe Magnus (NRM) are involved in reducing pain [3]. PAG, also known as anti-nociceptor, is important in the control of pain and surrounds the cerebral aqueduct in Mesencephalon [3]. When this region is electrical stimulated it produces profound analgesia and injection of morphine. PAG receives inputs from the thalamus, hypothalamus, cortex and the spinothalamic tract [3]. Neurons from the PAG region excite the cells in NRM which have a direction towards the spinal cord and block the pain transmission by the dorsal horn cells [3]. Stimulation of NRM produce a strong analgesia and release serotonin which activates the inhibitory interneuron and blocks the pain transmission [3]. The key neurotransmitter is noradrenaline and 5-hydroxytryptamine by modulation pain [3].

Neuropathic pain

Neuropathic pain is caused by a disorder in the somatosensory system and is often a chronic condition related to injuries or diseases [**Mindruta2013**]. The disease occurs at different levels in the nervous system and affects the signaling of pain [**Mindruta2013**]. The neuropathic pain would not be described as a single cause or a single specific lesson, but instead, they would be described based on a mechanism [**Mindruta2013**]. This mechanism can, however, produce painful symptoms in the same disease, but it would take different aspects [**Mindruta2013**]. The sensation is described as a sudden pain which is burning, tingling, shooting stabbing or numb and can be paroxysmal or continuous. The pain can be divided by the evoked pain into the following:

- Hyperalgesia is the pain of abnormal severity followed by a noxious stimulation.
- Hyperpathia is an exaggerated and prolonged response to stimulation, which can be delayed in onset and after repeated stimulation.
- Hyperaesthesia is defined as an increased sensitivity to stimulation.
- Allodynia is a painful response to a normally innocuous stimulus.
- Dysaesthesia is an evoked or spontaneous altered sensation is described as a discomfort rather than pain.

It can be difficult to localized the distribution of pain because the distribution is no longer respect by nerves, roots, segments, proximal or distal territories as for nociception pain. However, neuropathic pain can be divided into peripheral, central or mixed syndromes correspond to the anatomy and the underlying disease [**Mindruta2013**].

1.2 Pain measurements

Pain is described as a complex and subjective experience that poses a number of measurement challenges due to its subjective nature. Nevertheless, pain measurements are

necessary for pain studies as well as the evaluation of methods to control pain [**libro pain**]. There is no valid and reliable method of objectively quantifying pain at the moment. However, despite the challenges that pain measurement present, several tools and approaches can be employed in order to collect useful pain estimates [**pain outcomes paper**]. The aim of pain assessment is to diagnose the cause, understand the impact, identify appropriate pain relief strategies and evaluate their effectiveness.[**art and science**]. There are different dimensions of pain experience that can be assessed: pain intensity, pain affect, pain quality and pain location.

1.2.1 Self-reported scales

Pain cannot be registered directly by clinicians, why patient self-report is frequently used to asses the experiences of pain[**libro pain**]. Within this category it is possible to apply unidimensional and multidimensional scales. Due to the fact that pain is a multidimensional experience, it is needed a multidimensional assessment.

Unidimensional scales

Unidimensional scales explore only one dimension of pain. The most common assessed dimension of pain is intensity. This could be due to the fact that patients are usually able to provide quantitative pain intensity relatively rapidly [**libro pain**]. One commonly used unidimensional tool is the Verbal Rating Scales (VRS) which consists of a list of adjectives describing different levels of pain intensity. It is important for an accurate measure using this scale to provide adjectives which reflect the extremes of the dimension, as well as additional adjectives to represent the different levels of pain. Patients are asked to select the word that best describes their level of pain intensity. VRS are usually scored by listing the adjectives in order of pain severity and assigning each one of the scores as a function of its ranks. This type of scales are easy to administer, score and apprehend. However, it has several statistical disadvantages and criticism raised due to the fact that assumes equal intervals between adjectives [**libro pain**]. For this particular reasons along with others it is used when the patient's conditions require it [**six methods paper**].

Other possibility of unidimensional scales is a visual analogue scale (VAS). VAS consists of a 10 cm line, the ends of this line are labeled as the extremes of pain. Patients are asked to indicate the point along the line that best represents the intensity of their pain. The scale is scored by measuring the distance from 'no pain' end to the patient's mark. They are usually measure in millimeters thus, for a 10 cm line gives a high number of response categories. This fact makes the VAS more sensitive to changes in pain intensity. However, one of the drawbacks is that scoring time is higher than for other methods.

Numerical Rating Scale (NRS) is also within unidimensional tools of pain intensity measure. NRS consists of asking the patient to rate his or her perceived level of pain intensity on a numerical scale from 0 to 10 (or from 0 to 100), being described 0 as 'no pain' and 10 or 100 equal to 'higest level of pain'. The advantage of NRS is that it not requires

patients mobility because the response is given verbally. NRS is a valid method and demonstrate positive and significant correlations with other measures of pain intensity [**six methods paper**].

Another method is to use pictures or face scales to illustrate facial expressions of different intensities of pain. Even though the primary purpose of this scales were to offer individuals with written language or cognitive difficulties an option to express pain intensity, there is evidence that they are valid methods [**libro pain**].

Multidimensional scales

Multidimensional scales are convenient in relentless pain conditions. Multidimensional scales measure several dimensions of pain with different combinations of these dimensions. These scales offer a more detailed reflection of the patient's pain experience [**art and science**].

Within this category the McGill Pain Questionnaire (MPQ) is used. This method consists of 78 words that describe the pain in sensory, affective and evaluative terms. These tems are arranged in groups acoording to the quality of pain and intensity of this pain. A 6-point VRS is used to determ the intensity of the pain. The MPQ is proved as a valid method support by several studies [**libro pain**]. One disadvantage of the MPQ is the length and complexity, why a brief form of this questionnaire has been introduced, the short-form McGill Pain Questionnaire (SF-MPQ). The patients are able to rate the pain with 15 different descriptors in sensory and affective terms. Each descriptor is rated on a 4-point scale. The SF-MPQ includes a VAS for pain intensity as well as a VRS for rating the overall pain experience.

Another scale, breif pain inventory (BPI), was developed to assess cancer pain and have been proven as a useful instrument to asses different kinds of pain in several clinical settings [**libro pain**]. The BPI measures pain severity, pain quality and the disturbance caused in the patients daily life. Two subscale scores pain intensity and pain interference.

1.2.2 Psychophysical methods

Quantitative sensory testing (QST) evaluates the integrity of the entire sensory neuraxis receptor to the cortex. Even though QST has recieved criticism for being subjective, it is a reliable test. Brain imaging studies provided evidence that subjective pain magnitude scores are associated with objectively measured neural activity in areas of the brain involved in pain processing. QST include different modalities of stimulation, such as thermal, mechanical, electrical, ischemic and chemical. This method provide two different assessments of pain. On the one hand the evaluation of endogenous pain, which is the pain that the patient experiences due to the disease process. On the other hand, the assessment of induced pain, in order to experiment on pain mechanisms or therapy. [**neurop_exam**]

Measurement of experimental pain

As a result to a set of experimental noxious stimuli, it is possible to obtain different parameters such as, pain thresholds, tolerance or suprathreshold pain intensities. Threshold is defined as the stimulus that produces an arbitrary, but defined, level of performance. There is a distinction between receptor or absolute threshold and psychophysical or sensory threshold. Absolute threshold is the energy required to elicit response in the primary afferent while the psychophysical or sensory threshold, is the minimal energy necessary to reach perception. Due to the fact that receptor threshold is lower than sensory threshold, the sensory threshold is a convenient parameter which offers the transition point between non-painful and painful stimulus [**neurop_exam**].

Psychophysical Procedure

Psychophysical research has been mostly concentrated on thresholds measurement owing to, the desire to isolate low-level sensory mechanisms using operationally defined tasks that are intended to minimize the roles of perception and cognition [**psy_methods**]. There are different procedures in order to measure thresholds.

Methods of adjustment

The test subject adjust the magnitude of a stimulus, until a prespecified criterion is reached. This method is commonly used for appearance-based tasks. Currently, this method is not commonly used to obtain performance measures, due to the fact that forced-choice procedures are consider superior. However, the method of adjustment is useful for obtaining a rough threshold estimate to guide the choice of stimulus magnitudes for a forced-choice procedure, when there are different conditions to be measured.

Methods of limits

In this method, different magnitude stimuli are presented to the test subject, in ascending or descending order. The subject indicates whether or not the stimulus are detected on each presentation. Accordingly, the threshold in each case is the stimulus magnitude at which the response switches from non perception to perception and/or vice versa. The patient's response cannot be evaluated if it is correct or incorrect. [**chapter3**]. One of the drawbacks of this method is the observer may get used to reporting that is perceiving a stimulus or not. As a result, he or she continues to give the same response even at stimulus magnitudes that are higher or lower than the threshold. This phenomena is the error of habituation. Contrarily, the observer may anticipate the response and make a premature judgment, which is call the error of expectation. Another disadvantages using this method is that the parameter value from perception to non-perception differ from non-perception to perception value, due to different artifacts [**hysteresis**].

Method of constant stimuli

The stimulus magnitude on each trial is randomly selected from a predefined set. This range is selected to straddle the threshold value. This method generates data, when this data fitted with the appropriate psychometric function, provides the most accurate

estimates of the threshold. The choice of this stimulus set sometimes demand pilot work to obtain an estimate of the threshold. The method of adjustment, as explained before, can be useful for this purpose. It is possible to use this method simultaneously with appearance-based procedures. The selection of the stimuli range is crucial. In order to avoid the problem of selecting an incorrect set, an adaptive or staircase procedure is apply.

Adaptive or staircase procedure
An algorithm, that analyzes the previous trials response, selects the stimulus magnitude on each trial. This method can be used simultaneously with conventional methods as well as with performance-based and appearance-based tasks.

Forced-choice Performance Procedures
Forced-choice tasks can be termed by Alternative Forced-Choice (AFC) or Interval Forced-Choice (IFC). In IFC procedures the stimulus are presented in temporal order. There are different varieties within forced-choice performance procedures, 2AFC procedures are the most popular in psychophysics. In this method, in each trial two stimuli are presented. One of this stimui is the target, which the test subject must select.

1.3 Treatment of chronic pain

There are several ways of treatment for chronic pain patients, depending on the modalities and intensity of the pain. Besides conservative methods, alternative methods are applied to reduce chronic pain. The benefit of the alternative methods is a treatment without the risk of negative side-effects. [5, 6]

None of the different treatment methods is enough or sufficient when applied alone. But a individual combination considering the needs of each patient alleviates the suffering of the chronic pain. At the moment it is not possible to cure chronic pain, but, as mentioned, to relieve the suffering. [5, 6]

1.3.1 Physical therapy

Physical therapy is applied with the aim to enhance the patients' flexibility, general fitness and musculature. This is achieved by motion exercises and passive joint mobilization to enhance the muscle function and the joint stability and mobility. A special program is adapted to the patients' needs. Components of this program might be moist heat, cryo therapy, ultrasound and transcutaneous electrical stimulation. Furthermore assistance can be provided by manual therapy or exercise, which is included to improve the physical fitness, achieve weight loss and decrease the risk of chronic diseases encouraged by inactivity. [5, 6]

1.3.2 Psychological therapy

Psychological therapy helps patients to reduce depressions or anxiety and enhance a positive attitude. Also it assists patients to identify necessary lifestyle changes and implement them. [5, 6]

1.3.3 Lifestyle changes

Habits or life circumstances can intensify chronic pain. Changes of the lifestyle may help to decrease chronic pain. It is known that the pain sensitivity is negatively enhanced by nicotine. Therefore quit smoking can be a step towards relieving chronic pain. Furthermore chronic pain patients often suffer from insomnia. Sleep hygiene should be applied to reduce the occurrences as well as the severity of the sleep disturbances. If insomnia is due to medication, it should be revised, if it is possible to change the medication to avoid medicine related insomnia. Obesity is a risk factor in the likelihood to develop chronic pain, besides, it encourages other health problems for example cardiovascular disease or diabetes. It is known that chronic pain occurs more often in people which are overweighted. This is encouraged by the side effects of obesity like psychological disability or musculoskeletal pain. To improve this condition, weight loss should be achieved by the combination of diet and exercises. This will influence the recovery abilities from pain positively. [5, 6]

1.3.4 Surgery

Surgery is a less frequent treatment technique. Commonly it is used to relieve patients from pain due to anatomic abnormalities. [5, 6] But also patients suffering from chronic low back pain can be treated by surgery. It is always necessary to weigh risk and benefits of surgery. Where appropriate it should be harked back to other and less invasive treatment options. [6]

1.3.5 Medication

Medication is a common way to treat severe chronic pain patients.Those medicaments can be divided in three groups, the coanalgesic medicaments, the non-opioid and the opioid analgesics. [5]

Coanalgesics

Coanalgesics are normally used to treat other diseases, for example depressions, but still provide analgesic qualities. They are often used to treat fibromyalgia, chronic headache and neuropathic pain. Often coanalgesics are combined with analgesicts to extended pain-relief. [5]

Non-opioid analgesics

Non-opioid analgesics are used to reduce intermittent mild to moderate pain. To this category belong nonsteroidal anti-inflammatory drugs, which decrease inflammation and give analgesic properties. Non-opioid analgesics are especially used in short-term-therapy. Non-opioid analgesics inhibit the prostaglandin synthesis. Prostaglandin has a protective effect. A permanent use of non-opioid analgesics encourages prostaglandin effects, which conduct in severe organ toxicity. Known side effects are for example gatrointestinal toxicity, pephrotoxicity and a increased risk of cardiovascular diseases. [5, 7]

Opioid analgesics

Opioid analgesics provide stronger analgesic qualities than non-opioid analgesics and show no prostaglandin effect. These analgesics work by bending in the central nervous system to the opioid or NMDA receptors. Because of this better long-term tolerability opioid analgesics are used in patients which suffer from chronic non-malignant pain. But the use of opioid analgesics accompanies with the risk of abuse and misuse. Studies have shown, that the median time until abuse behavior is 24 months. Treatment targets and specific requirements are set to minimize this risk. [5, 7] The decision, if non-opioid or opioid analgesics are used, is based on weighing safety, tolerability and effectiveness. The superior effectiveness and the lower organ toxicity of opioid analgesic outweigh the risk of abuse or misuse. [5]

1.3.6 Chiropractor

Chiropractic treatment is adjustment and manipulation of the spinal cord to alignment the vertebrae of the spine to reduce pressure on the nerves running down the spine. [8] In a study by [9] evaluating 506 patients with acute and chronic back pain after 3 month of chiropractic treatment. Patients undergoing chiropractic treatment showed improvements in their condition and the effect was ongoing after 3 month. [9]

1.3.7 Acupuncture

Acupuncture is a treatment where small sterile needles are inserted into the skin of the patient. The needles are inserted at specific acupuncture points related to the type of pain that the patient is experiencing. [10] In a study by [11] acupuncture has shown promising results in reducing pain in patients with soft tissue round the shoulder joint, headaches, neck and shoulder pain, arthritis/osteoarthritis and low vack pain. A total of 348 patients where evaluated. The mean reduction of the entire patient group where 68 %. Showing best results in soft tissue round the shoulder joint, showin a mean reduction of pain by 79 %. The headache and neck and shoulder patients had a mean reduction by 74 %. Patients with arthritis/osteoarthritis showed a mean reduction by 58 % and the patients with low back pain had a mean reduction by 50 %. In 80 % of the patients the effect of the treatment lasted for more than 3 month and 32 % over one year. [11]

1.3.8 Hypnosis

Hypnosis is a process where the one comes into the state of trance and feels deep relaxation and is open to conversation verbally. Hypnosis is a guided process and can be carried out alone or by others. [8] Factors as anxiety, depression and other states of mood and the general the social life of the patient has been shown to play a role in chronic pain. these mechanisms might be altered by hypnosis. In the literature hypnosis has shown positive to relieve pain, but only on a short term basis. [10]

1.3.9 Yoga

Yoga is a form of mind to body practice discipline, or tradition originating from India. In the practice of yoga different physical postures, breathing techniques and more are the routine. Yoga is both a form of personal evolution, but most popular because of the exercise which benefits the health. A review by [12] found that yoga could improve the functionality of the back and a slight effect of treating pain compared to non-yoga participants.

1.3.10 Mindfulness meditation

Mindfulness is often defined as being in the mental state of non-elaborative, non-judgmental awareness [**Zeidan2012**, 13, 14]. Mindfulness is viewed upon as a lifestyle and the lifestyle of mindfulness can be practiced through meditation, called mindfulness meditation. Practicing mindfulness meditation includes control over sensory, emotional and cognitive happenings. Hereby the ability to control these sensations without being distracted by them as so the ability to abstract from past and future representations of memory. Hereby one can say that mindfulness meditation is training of the mind. [14]

(.....MAYBE WE NEED SOME KIND OF REASONING TO WHY WE CHOOSE TO LOOK INTO MINDFULNESS MEDITATION, LIKE A SUMMARY OF ALL THE METHODS BEFORE GOING INTO MINDFULNESS MEDITATION, AND THEN DIG DEEPER INTO THE FACTS OF MINDFULNESS MEDITATION....)

Two popular practices of mindfulness meditation, focused attention (FA) and open monitoring (OM) are of the most well practiced types of meditation. [13]

Focused attention

FA is the training of concentration, where one keeps his or her focus at an object or specific thing, only focusing on that thing. Often the flow of breath is the focus, when practicing FA meditation. When any disturbance comes by, like a thought, sound or other environmental distractions, which will often lead to a drift in attention, the person should always bring his or her attention back to the focus. [13]

Open monitoring

OM is the cultivation of open presence, were the mind is open to anything, not focusing on any specific thing, just being in the present. If any thought or disturbance comes by, the thought or sensation should be noticed briefly, but then left without thinking more over it. It is believed that this form of meditation is easier to learn when the person masters the meditation of FA, whereby the OM form is easier to master. [13]

This kind of meditation has been shown to reduce pain more compared to FA, likely because the areas of the brain affected during this form of meditation is...[15]

FA and OM can alter pain in different ways... OM is more effective in reducing pain after extensive meditation training compared to FA. [**Varilly2012**]

Mechanisms of mindfulness meditation

Enhanced emotion regulation, cognitive control, acceptance and positive mood have been linked with health benefits as well as pain modulation. These mechanisms has been shown to be modulated during mindfulness meditation practice. A study by Perlman et al. ([15]) shows that practicing meditation could not lower the intensity of pain, but instead lower pain unpleasantness in the participants. [**Zeidan2012**, 15]

The typical response when using a placebo analgesia is increased activation of the dorsolateral prefrontal cortex during pain anticipation. Effect that predicts reductions in pain perception and activaty of pain related brain regions. Mindfulness meditation does not involve dorselateral prefrontal cortex activation. [**Zeidan2012**]

The findings on mindfulness meditation and pain modulation are split, but experiments in controlled settings are still needed to confirm if the effect of mindfulness meditation works on pain modulation. [**Zeidan2012**, 15]

Different brain regions are involved the practice of mindfulness meditation. The most important are the prefrontal cortex (PFC), involving the anterior cingulate cortex (ACC) and the medial PFC as illustrated in figure 1.2. The striatum, the insula and the default mode network (DMN), which include the medial PFC and the posterior cingulate cortex (PCC). These regions play a big role in the effect of mindfulness meditation and are highly regulating the mechnisms of meditation which can generally be catergorised into the three catagories, attention control, emotion regulation and self-awareness.

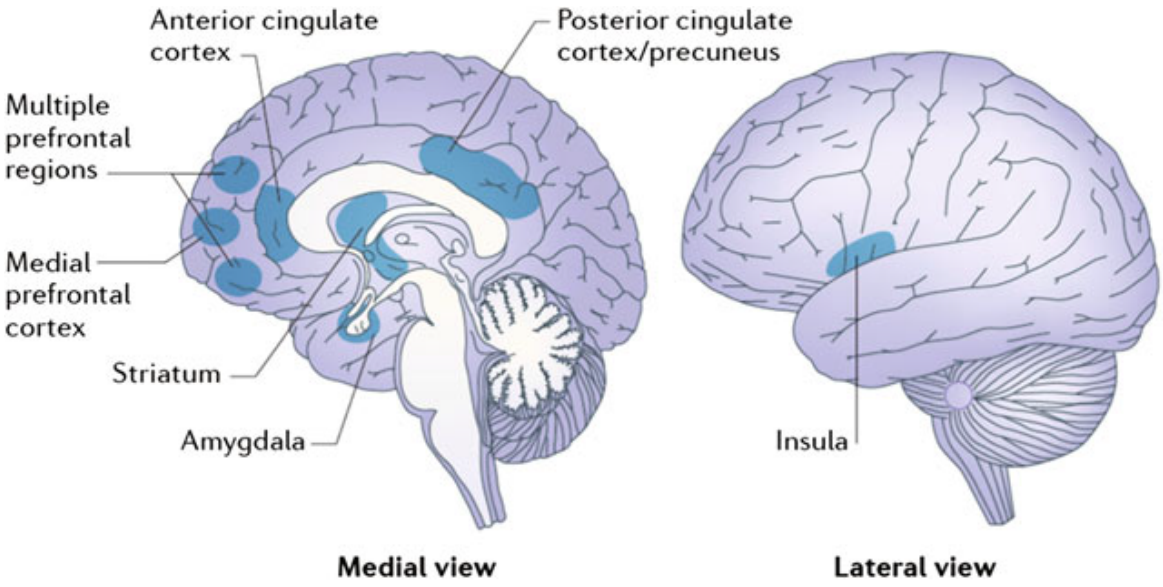

Figure 1.2: Image of the brain highlighting specific regions relevant when practicing meditation [14]

Attention control

Attention control is the ability to maintain focus, for instance on the breath during FA meditation. This mechanism includes mainly ACC, PFC and the striatum. Increased activity in the dorsal lateral PFC is required to hold an increased attention, aswell as deactivation of the areas of the brain that makes the mind drift, which include the medial PFC. [14].

Emotion regulation

Emotion regulation include the emotions that arise, when they occur and how they are experienced and expresed. This mechanism involves multiple prefrontal regions, limbic regions and striatum, which are regions primary in regulating the emotional thoughts through the limbic system also responsible for goal setting. This need for regulating the emotional control is important because during the meditation practice the participant must be able to handle bordom or negative mood during the meditation. Stronger subgenual and adjacent ventral ACC activity with meditation. This brain area is involved with emotion regulation and attention control. also the dorsal lateral PFC and amygdala plays some role in regulation of emotion.

Self-awareness

Self-awareness includes the awareness of one self, the awareness of being conscious as well as meta-awareness which is the awareness of the internal bodily state. Regions of the brain involves midline cortical structure DMN, ACC, the insula, medial PFC and PCC.

Reduce activity in midline cortical structure including the DMN, more reduction in the posterior part PCC, than the antoerior part medial PFC, but increase in perigenual ACC activity.

Meditation practice

Different expertises of meditation, early, middle, advanced appear to modulate the dynamic balance between anterior and posterior midline networks involved in different aspects of self, cognitive self, bodily self, and phenomenal experiential self. This reflects self plasticity following meditation. The effort to get into the meditative state takes varies according to your experience level with meditation. Often this experience level can be divided into three stages, early, middle and advanced practice of meditation. These stages determine how much effort one must use to get into the meditative state [14]. These stages is illustrated in figure 1.3.

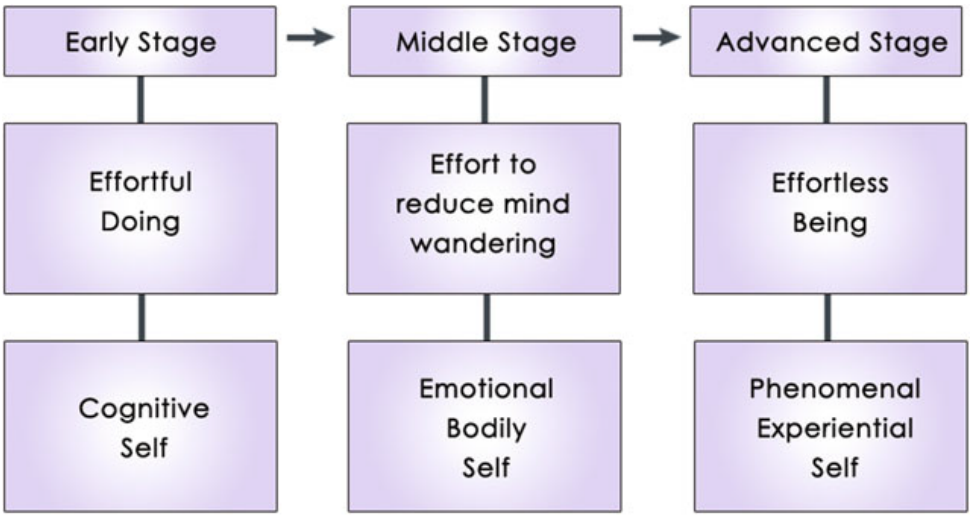

Figure 1.3: The three stages of meditation practice, describing how much effort one must use to get into the meditative state
[14]

In the early stages more mental effort is required, here the dorsal lateral PFC and partial cortex are often involved and activated more. A stronger deactivation in the DMN is shown to occur when using more effort. With less effort, the ACC and striatum will participate more. [14]

The method of mindfulness meditation will not make the pain go away, but the patient will be able to deal with the pain easier, as mentioned, making the patient engage more in the treatment than focusing on and reeling on the medication. [16] Even short-term mindfulness training can have an effect. The study by [**Zeidan2012**] is explaining an effect of training mindfulness meditation examined for 20 min sessions for four days of mindfulness meditation, but most studies conduct the experiments for a period of more

than six weeks. [**Zeidan2012**]

The neural mechanisms behind mindfulness meditation in reliving pain has been researched and in experiments where stimulating with nociceptive pain there has been shown an increase in activity areas of the PFC when meditating. Participants telling that they are able to feel the pain but able to deal with it better during meditation focusing on the breath. The same mechanisms working in analgesia is not the same as the mechanisms during meditation, why the two methods don't interfere with each other. [16]

The different areas of the brain show either a reduction or increase in activity when performing meditation. When practicing meditation the person trains the mind, and areas of specific regions will grow. [**Zeidan2012**]

Examining long term meditators, the findings are a thicker gray matter in mid cingulate cortex and bilateral secondary somatosensory cortex, which are involved in pain related regions overlapping the functional effect. A correlation with the number of years practicing meditaiton and the mid cingulate was also found. This gives evidence to long lasting effects of meditation. [**Zeidan2012**]

2 | Methods

3 | Data analysis

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