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Meditation and Breathing- A Review

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ABSTRACT

The age-old practice of meditation and deep breathing, traditionally found and followed by the people in South-east Asia, has gathered attraction all over the world. Despite many researchers investigating this practice and its benefits, only recently have the neurophysiological studies been able to highlight the nuances of its effects. The present article is a review of literature on meditation and deep breathing. The focus is also on the cognitive aspects, mainly the attentional processes, which are influenced by this practice.

1. Introduction

Over recent times there is a lot of talk about meditation. Meditation is understood differently by different persons and cultures. Meditation is an awareness or consciousness about one's thinking. An attempt to calm the thinking process. It is not a process of blocking the thoughts or feelings but learning to observe them without being judgmental. Meditation is viewed in the Eastern world as a spiritual tradition. Over the last 2 decades meditation and deep breathing exercises have gathered attraction from all parts of the world. It is no longer seen as just a spiritual tradition but is also found to be useful to de-stress in real life circumstances and often recommended as a part of therapy. In the Western world meditation has a positivist orientation. It is considered as an alternative mind-body therapy (Hussain & Bhushan, 2010).

Meditation encompasses a variety of practices aimed to promote relaxation, and calm the body (Davidson and Lutz, 2008). In Buddhism, meditation is for awareness and enlightenment. Buddhism believes meditation is the practice of detachment (non-attachment) to everything, even the thoughts and feelings that we are experiencing (Wright, 2017). One important aspect of yoga is meditation. Meditation is beneficial in improving the sense of well-being, attention and ability to inhibit discursive thoughts and stimuli. Earlier studies have found its impact on physiological and cognitivenature. Woolfolk and Rooney (1982) found that subjects who received five sessions of training in the meditation treatment showed a significant reduction of stress symptomatology, cognitive and somatic manifestations of daily stress.

Meditation is a mind training process that can be achieved by various methods. Some of the methods for meditation could be mindfulness, focused meditation, mantra meditation, visualization meditation. Focusing on breathing is considered the simplest technique to calm the mind and meditate. The age-old advice given by our grandparents to 'calm down and take a deep breath' has recently gained a lot of attraction from the field of neuroscience. What was seen to be common knowledge, researchers from many fields, like psychology and neuroscience, have now come forward to support these benefits. Along with enhancing immediate cognitive functions, the effects have long lasting impact, as it is also seen to offset the age-related decline of cognitive abilities (Luders, 2014). In some cases, older adults are seen to have improved cognitive functions. In contemporary times the techniques of meditation have been frequently used in clinical settings. (Kabat-Zinn et al., 2000).

The present article is a review of literature aimed to understand and highlight the quantifiable impact of meditation and deep breathing. A special focus is on the cognitive aspects and attentional mechanisms that benefit from deep breathing. Even though many scientific studies and have been conducted through many years, only recently, in the last decade, have researchers started uncovering the nuances of the exact neurophysiology benefits of the process. Earlier researches were seen to lack strong experimental design, with respect to the control groups and the scientific rigor. The effects were found in the form of weak statistical evidence for these studies. Another point which leads to highlighting the discrepancy found in the existing literature is the lack of a clear, operational definition for mediation.Each researcher defines the process in their own way, which causes ambiguity. Different meditation styles like Vipassana, Tibetan Buddhism and Zen can result in producing diverse effects.

Lutz, Slagter, Dunne and Davidson (2008) in their review paper classified meditation into: Focused Attention (FA) and Open- Monitoring (OM) meditation.

Focused Meditation

Focused Attention (FA), necessitates persons to voluntarily focus attention on an object for longer amount of time. Any objector visualized image can be selected to aid the individual. A common practice among meditators is also to focus on their own breathing and use it to sustain attention. For people to reach the state of meditation, there exists a constant need to monitor and regulate the quality of attention. During the training period, novices are guided step-by-step and are reminded to bring their attention back to the focused object (Colzato et al, 2015).

This form of meditation focuses on three regulatory functions. Firstly, sustaining attention requires vigilance to distractions, without diminishing focus on the intended object. The second function is to cultivate the ability to disengage from distractors. Lastly, the individual is required to promptly redirect focus to the intended object (Slagter et al, 2011). Slagter in his

review also highlighted the parallels between the tenets of Focused Attention meditation and Posner's definition of attention. Posner defines the core components of attention as the ability to maintain alertness or optimal sensitivity to external stimuli, and to be able to select relevant information or stimuli from the environment (Posner, Boies, 1971). Both the definitions can be broken down to be proposing comparable concepts.

Lutz et al, (2008) in his review highlighted the brain areas involved in the various regulatory mechanisms employed in FA meditation. Brefczynski-Lewis et al, (2007) examined the neural correlates of FA meditators and found that distinct regions activate from the mechanisms. The dorsolateral prefrontal cortex saw greater activation while monitoring, while the visual cortex and superior frontal sulcus were implicated in engaging and orienting attention, respectively. These induced changes are reflected in the improved results in the behavioral studies measuring attention.

Open Monitoring

The other style of meditation is Open- Monitoring (OM) meditation which involves the individuals to monitor the content of their experiences non-reactively, without focusing on any one object. It can primarily help in recognizing the nature of the cognitive and emotional patterns. Often people get stuck on and are unable to move past negative emotions like anger or jealousy or even disturbing thoughts. These people greatly benefit from this form of meditation. OM meditation is often considered the higher form of meditation, as it typically requires a calm mind. Traditional forms of Zen meditation, Vipassana, and mindfulness techniques arecategorized under OM. This is accomplished by not attending to the distractions, using the FA meditation. Techniques like deep breathing, chants and visualized forms are an integral part of OM, but are used as a means to reach the calm state after which individuals subsequently discounts the attention paid to the explicit object. It leads to an increased awareness of sensory, perceptual and salient stimuli, but also boosts the non-reactive monitoring of the stimuli. Taken together, it leads to increased cognitive flexibility and enhanced reappraisal strategies (Chambers et al., 2009).

Studies have found improved conflict monitoring in participants who have undergone five days of meditation, when compared with the control group (Tang YY et al, 2007). The increased non-reactive monitoring in practitioners also expanded to homeostatic afferent activity of the body, be it temperature change or pain. A greater activity in the neural circuitry, particularly anterior insula, anterior cingulate cortices was found in participants after they completed an eight-week course of OM meditation (Kabat-Zinn et al, 2000). The reappraisal behavior in the form of regulatory mechanisms of emotional processes has also found support and has extended itself to the clinical field. The labelling of affective responses to situations (I am in distress) or stimuli are seen in Vipassana traditions (a technique which falls under OM), and is a common practice adopted in the clinical settings. Lieberman et al, (2007) in their study examined the neural correlates for affective labelling. They confirmed the activation of right ventrolateral prefrontal cortex and attenuation of amygdala responses when asked to verbally label affective stimuli. This is suggestive of reduced duration and intensity of automatic affective responses due to inhibition in the appraisal systems and finds individuals to be better equipped to deal with emotional situations.

2. Breathing exercise and meditation

One of the primary techniques of meditation, especially in FA meditation is deep breathing. Breathing exercises induces an altered state of consciousness with the help of activation of the parasympathetic nervous system (Brown and Gerbarg, 2009). Some of these exercises are breathing deeply from the abdomen, alternatively breathing through both the nostrils, or only one nostril, holding breath at different points in the breathing cycle, i.e., after inhaling completely or after exhaling. The physical posture and awareness of your breath is also important while performing these breathing exercises. Different forms, be it in technique or the pattern elicit diverse effects. Peng et al., (2004) examined heart rate dynamics and cardiopulmonary interactions during three different breathing patterns. They noted common effects of the various breathing patterns on heart rate, but also some specific responses. The researchers found that the heart- rate respiratory coupling depended on the exercise. In other words, different breathing patterns induce different effects in individuals. Two techniques, namely relaxation responses and segmented breathing, invoked high amplitude, low frequency oscillations along with significantly increased heart rate and breathing coherence. On the other hand, the third technique showed a significantly decreased coherence between heart rate and breathing, while also displaying a pattern of decreased overall heart rate variability.

Along with observing variations in heart rate variability, breathing exercises also have various physiological and neuro-physiological effects (Dijk, 2018). Michalsen et al., (2005) found alterations in hormonal levels, wherein a group of distressed women showed decreased levels of salivary cortisol after an intensive three-month period. Studies have also validated claims of significantly reducing both diastolic and systolic blood pressure after brief alternate nostril breathing exercises ranging from 10 to 25 minutes (Telles, et al., 2013; Telles, Sharma, and Balkrishna, 2014; Telles, Verma, Sharma, Gupta, and Balkrishna, 2017). Cheng et al., (2018) also found increased levels of activity in the frontal theta power in the group when practicing breathing exercises. The inverse relationship between frontal theta power and anxiety is indicative of breathing also changing anxiety levels in individuals.

Lately, deep breathing has seen an extensive body of literature affirming its effects on different cognitive functions. Gothe et al., (2013) studied the effect of various shorter interventions (aerobics exercise, yoga exercise, and control group) on executive function measured through tasks. The study found persons having improved performance (shorter reaction time and improved accuracy to the stimuli presented) after the yoga session, as compared to individuals in aerobics and control group. These results linked increasing working memory load and cognitive control to practicing yoga exercises. Busch et al. (2012) observed participants exhibiting significantly increased detection and higher pain thresholds for stimuli after deep breathing practice. Similar effects were extended into the field of learning, as researchers found single trial of 30 mins breathing practice can significantly improve retention of motor skills (Yadav and Mutha, 2016).

McKay, Evans, Frackowiak, Corfield (2003) reported significantly increased activity in the medulla. Increased activity in the medulla is suggestive of the role played by the brain stem in mediating voluntary control in breathing. Recently, researchers have found evidence supporting the effects of breathing. Herrero et al., (2017) examined voluntary control and attention to breathing and their effects observed in the brain areas using an intracranial electroencephalogram (iEEG). Merely paying attention to breathing can increase the coherence of various areas of the brain as in the premotor, hippocampal, insular, and anterior cingulate cortices. Volitional breathing, or being conscious about one's breathing, is found to increase coherence between the frontotemporal- insular network. A greater coherence in the network is reflective of greater strength and integrity of the connections.These findings are indicative of the neurophysiology of breathing and the activations that lead to greater evidence for breathing to mediate the neuronal oscillations through circuitries in the brain. Melnychuk et al., (2018) in their study identified the locus coeruleus (LC) (nuclei in the pons) as an agent to synchronize the respirational and attentional systems. These studies together are indicative of the coupling of breathing and attention and the impact of modulating breathing on attention.

3. Breathing exercises and Attentional mechanisms

There have been various studies examining the link between meditation and attentional mechanisms in the form of behavioral and neurophysiological findings. Eysenck et al., (2007) examined the effect of meditation on attention, and found that simply reducing anxiety diminishes the effect of stimulus- driven attention, i.e., people are less prone to get distracted by stimuli in their environment. In turn the decrease in anxiety, helped enhance the performance of goal-directed attentional systems.

To examine the existing literature on the impact of deep breathing on attention, the research studies found, were categorized based on how long the participants have practicedmeditation. The three main categories were: *expert meditators* (with many years of practicing meditation), *long-term intervention* (individuals practicing meditation for 8-16 weeks), *short- term intervention* (short interventions upto 8 weeks). Studies in all three categories found significant effect, either as behavioral data or neuronal findings, on attentional systems.

4. Expert Meditators

Persons involved in meditation for many years are seen to have improved performance in multiple factors of attention. Research studies also support expert meditators to have expertise associated to changes in activation in brain regions. Cortical thinning is generally associated with ageing and progressions of diseases, individuals practicing compassion and insight meditation were seen to have increased cortical thickness (Lazar et al, 2005).

Makowski et al, (2019) studied mindfulness, a component of meditation which is described as a non-judgmental present moment attentional stance, as a trait in individuals. The researchers wanted to investigate the link between dispositional mindfulness and feedback to emotional stimuli. They administered a mindfulness questionnaire on their participants to be able to score them on their dispositional trait of mindfulness. The Rapid serial visual presentation (RSVP) paradigm was used to check for emotional attentional blink. The findings suggest that higher scores in the non-reactive facet of the mindfulness questionnaire (Baer et al, 2006), related to quicker disengagement of attention by emotional stimuli. The participants with increased trait mindfulness had a higher recognition of the negative distractors. This is evidential towards non-reactive behavior of individuals not being associated with less attentional engagement, rather individuals being able to disengage with the emotional stimuli faster. It could further be extended to claim fostering characteristic traits associated with meditation in individuals. These individuals could aid allocating resources better and help the disengagement process to shorten their reaction to the negative stimuli.

Studies have hypothesized that like other skill- related learning be it cycling, swimming or driving, meditation too follows the same curve. When initially learning the skill, people have to be more attentive and concentrate on the smaller aspects of it. Eventually, with greater time and practice hours people master the skill, it is also seen that the skill becomes easier and requires less cognitive resources. Brefczynski-Lewis et al., (2007) studied expert meditators (EM) from Tibetan Buddhist traditions to the effect of long-term meditation in terms of neural activation. They were amongst the first to find fMRI bases for this effect. Individuals in the EM group had large variability with respect to the number of practiced hours, ranging from 10,000 to 54,000 hours. The expert meditators were then classified into two groups, longer hours expert meditators (MHEM), lesser hours expert meditators (LHEM). Control group were novice meditators,they were age-matched to EM. They were given one week of practice prior to the experiment. The experiment design was followed by two alternative states in a block paradigm in an fMRI scanner.First is the concentration meditation phase (fixating on a small dot on screen), the second is the rest phase. The participants were exposed to positive, neutral or negative sounds as external distractions in the two phases also. The findings showed variation in activation in attention- related regions, in terms of time and strength course of the activation, among the novice meditators and EMs. The novice meditators showed greater activation in medial frontal gyrus, anterior cingulate regions that are often shown to be inversely correlated in tasks related to sustained attention. In other ways, they found it difficult to sustain attention. It was also seen that activation in the brain areas while concentrating could also be correlated with the hours of practice for expert meditators. When comparing the three groups, it was observed that LHEM had the highest activation, significantly greater than both MHEM and novice meditators. Suggestive explanation for the same is provided in texts which describe meditation to require more effort initially, subsequently requiring minimal effort to alert and sustain focus. This correlation is seen to be indicative of fitting the inverted u-shaped function often used to describe skill learning (Sakai, 2005).

Activation differences could also be explained in terms of cognitive resources allocated for the task. Expert meditators are hence seen to require less cognitive resources to perform the task without compromising on performance, resulting in diminished activation and perhaps fewer processes competing for resources (Slagter et al, 2007).

Long-term Intervention

Meditation and breathing are heavily used as an intervention for clinical purposes and is followed by many practitioners. The typical training period for meditation and interventions span over 8- 16 weeks, which for the ease of our review is termed as Long-term intervention. Multiple studies have been conducted keeping in mind this training period. Mindfulness- based stress reduction (MBSR; Kabat-Zinn et al, 1992) comprising aspects of yoga are often found to be conducted for this time period. These studies have conclusively contributed to the mechanisms and functions of attention (Williams, 2010). The studies discussed below have breathing exercises as the technique used for meditation.

For an overall effect of breathing on mental health, Ma et al., (2017) investigated the effect of deep breathing on cognition, affect and stress. They trained participants for 20 sessions, conducted over 8 weeks. The data of the breathing group, when compared to the control, reflected lowering of negative affect across the 8 weeks. They also found better accuracy for the Number cancellation task, which is seen to test for sustained attention. The cortisol levels as a response to stress also were found to be lowered after the intervention period, demonstrating positive effects for deep breathing.

Moore, Gruber, Derose and Malinowski (2012) examined the effect of brief breathing exercises on self- regulation of attention and the neuronal activity related to attentional control, by using a behavioral study and an electroencephalograph (EEG) study. The study was conducted with two groups- the rest group and the meditation group, 20 participants were included in each group. They were given training for three hours, followed by meditation for 10 mins per day for 16 weeks. They were tested in the middle of the study at week 8. The rest group, on the other hand, was the control group who did not undergo any such training. A Stroop test was conducted on the participants for testing conflict monitoring and inhibition. It was found to have enhanced performance by the end of 16 weeks. The meditation also enhanced the N200 event-related potential (throughout the intervention). N200 waves found in EEG study results are reflective of executive cognitive control functions in the brain. Post- stimuli display, N200 was seen to have an early effect implying of improvement in resource allocation. There was an effect on P300 ERP also, suggesting the reduced resources utilized for object recognition, thus, without compromising on the performance, participants were allotting optimal resources to the task. Theresearcher has termed the efficiency of allotting resources as self- regulation of attention by the researchers.

Stretching the claim that meditation alter resource allocation for attention was also tested with another paradigm of the attentional blink by Slagter et al, (2007). The study investigated the effect of 3 months of rigorous meditation and the effect on the neural correlates. TheRSVP task was administered to attend to two stimuli presented consecutively. Attentional Blink (AB) is a phenomenon often seen in people when they must identify two visual stimuli, the accuracy of the second stimuli (T2) is often affected if it follows the first stimuli (T1) within 200 to 500 milliseconds. Behaviorally, in Slagter et al (2007) study, it was observed that the resulting smaller blink was reflective of the effect by the intervention. Based on the ERPs, it was also observed that participants reduced the brain-resource allocation for T1. A substantial link was noticed between the participants who displayed a decrease in resource allocation to T1 and reduced attentional blink size. Thus, correct identification of T2 was largely based on the optimum resources deployed to T1.

Brief Intervention

The researchers have observed conclusive effects of meditation on participants who were trained over months and years. In the contemporary times, there has been a huge interest in studying whether and how brief interventions of meditations will affect cognition and body. Various studies have aimed to understand comparable results when handling smaller, more brief interventions. Tang et al., in 2007, investigated the effects of 20 minutes of meditation each day, for continuous five days on the executive functions and self-regulation. In the study they used the Attention Network Test (ANT) to study the executive functioning, as it relates to conflict monitoring and inhibition, and also with testing intelligence, profiling for mood states and stress- related cortisol levels. The participants' finding reflected the improved scores in ANT, with a decrease in cortisol levels, and reduced anxiety, anger and depression. The brief intervention was found to increase the immunoreactivity.

In 2005, Wenk-Sormazobserved effects for brief intervention for evena short time of 20 minutes of meditation. They examined habitual responding and cognitive frames. Spread over cognitive tasks like the Stroop task, work production task and category word production. It was found there exists an increase in non-habitual responses. Thus, brief meditation interventions can be beneficial to reduce habitual responding.

Another study on meditative interventions as short as 10 minutes by Norris et al., (2018), were able to confirm the effects found in earlier studies. It was found, there is better accuracy of participants on the Flanker task, with the meditation group, in comparison to the control group. Even while performing the ANT, individual persons belonging to the intervention group had enhanced scores. It was observed that the differences in the ERPs across both groups, with larger and earlier N2 to incongruent trials. This supported the claim that even brief meditation improves the attentional resource allocation in novice meditators.

5. Conclusion

As seen in the review, deep breathing and meditation have shown to greatly impact people in both the physiological as well as the psychological aspects. Individuals practicing meditation for longer periods of time have shown improvement in many aspects. One of the primary fields of application of meditation and breathing interventions is seen with the clinical population. A team of researchers studied the effect of 8 weeks mindfulness intervention with chronic pain patients. These patients are hypervigilant and selectively attentive to stimuli related with pain. After 8 weeks of intervention the patients reported reduced attentional bias related to pain. They also scored higher on perceived control over pain and attenuated reactivity.

A recent surge of scientific evidence backing the effects of meditation, along with the widespread usage in therapy, brief period meditation is also catching attention. For most people constraints with regards to time, money and teaching faculty

act as a deterrent for learning and practicing meditation. Many people also find it difficult to get themselves to focus and concentrate. Motivated by these shortcomings, brief meditation training has gained popularity across the globe.

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