Abstract : **Effect of Meditation on the Brain with implications for Emotional Intelligence**
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This paper correlates the findings of research done in the field of Neuroscience upon volunteers with varying degree of expertise in meditative practices with the concerns of the interdisciplinary field of Emotional Intelligence.
Armed with PET, fMRI and the latest EEG equipment, scientists are now able to study the working brain. The recent discovery of Adult Neurogenesis supports the findings of increased cortical thickness and lasting changes in the brain brought about by training and long hours of practice. The practical implications of this work lie in the realm of Emotional Intelligence as the effects are found to involve brain areas that participate in self awareness, emotional regulation, decision making, social appropriateness, empathy and theory of other minds. It also corroborates that voluntary invoking of positive and socially beneficial emotions is a trainable skill. Meditation is found to reduce the production of stress hormone through calming action on the HPA axis.
Experience and training change the brain. This is expressed by the baseline changes in EEG and increased cortical thickness in certain areas found in experts in meditative techniques. These changes are brought about through the process of neurogenesis which is hampered in the presence of stress hormone. Meditation is a voluntary technique for stress reduction.
Although these studies have been conducted on volunteer monks, meditation is fundamentally no different from other forms of skill acquisition and mental training that can induce neuroplastic changes in the brain.

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Effect of Meditation on the Brain with implications for Emotional Intelligence

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Not very long ago, 1999 to be exact, Elizabeth Gould's research results on marmoset monkey brains (Gould et al 1999 *Science*) overturned a basic biological concept that was almost entrenched as a dogma. Earlier workers (Pasko Rakic, Cajal) had shown that new neurons are not born and the nervous system was thought to be fixed and unable to regenerate. Gould's studies showed newborn neurons in adult brains. She took years to receive recognition after she steadfastly unearthed hitherto ignored work of Joseph Altman and Michael Kaplan who had demonstrated neurogenesis but had been criticized so severely that they had withdrawn their claim. Today Neurogenesis is a field of study and a cause for optimism. Gould's further study has been on the effect of stress on neurogenesis and has shown that newborn cells prevent the onset of depression and that elevated cortisol level (stress mediating hormone) suppresses neurogenesis (Mirescu et al 2006 *Proc Nat Acad* Sci).

The above finding can be interpreted thus: New neurons are associated with learning and training. Acquiring new skills prevents depression and stress hampers learning.

The implication of this research is of great significance to the study of Emotional Intelligence especially when coupled with the findings of brain studies conducted on monks who have extensive meditative practice.

It is now accepted that experience and training cause changes in the brain (Gould et al 1999 *Nature*). This phenomenon is called 'Neuroplasticity'. The researchers suggest that mental training of meditation is no different from other forms of skill acquisition. The changes that occur are in accordance to the circuits being used in the activity being mastered, e.g, learning how to juggle is associated with the areas in the cortex processing visual motion. The changes are expected to involve the development of new connections between existing neurons and inclusion of newly born neurons into new or existing circuits. The new cells would contribute to an increase in thickness of the tissues detectable in scans.

Studies have been conducted using Positron Emission Tomography [PET], functioning Magnetic Resonance Imaging [fMRI] and Electro Encephalography [EEG] in many research centers. I will refer to the work done Waisman Laboratory for Brain Imaging and Behavior at the University of Wisconsin-Madison under Richard J Davidson and Antoine Lutz.

In meditation the areas of the brain that show activity are those that participate in **focus of attention** (pre-frontal cortex, visual cortex, superior frontal sulcus, supplementary motor area and intraparietal sulcus) (Davidson, Lutz 2008 *IEEE*) and during compassion meditation regions critical to **empathy** (Insula, somatosensory cortex, Anterior Cingulate cortex) are activated as well as areas linked to mentation of **mental states of others** (Temporal lobes, temporo-parietal junction, medial pre-frontal cortex and posterior cingulate) show activation. Stronger activity is detected in the right hemisphere than in the left.

Types of Meditation

Focused Attention [FA]

Most meditative techniques begin with learning to focus and sustain attention. An external object may be used to maintain visual attention or the practitioner may remain aware about the breath or a part of ones own anatomy. Beginners find it hard to sustain attention while experts are able to do it quite effortlessly. This method may be used to calm down a person sufficiently to be open to other forms of meditation. Experts were found to have less activation in the amygdala (Emotional Center) in response to emotional sounds. This supports the idea that **emotionally reactive nature is incompatible with stability of concentration**. The experiments prove that sustaining concentration is a trainable skill.

Open Monitoring [OM]
In open monitoring type of meditation the aim is to reach a state in which no explicit focus on any object is retained and one is attentive moment to moment to anything that occurs in experience in an experiencing and non-judgmental way (e.g. as practiced in Vipassana and Mahamudra).

Compassion Meditation
Practice of emotional types of meditative techniques involve voluntarily generation of positive emotions such as loving-kindness-compassion state, or attitude of gratitude. Experiments demonstrate that specific recordable changes occur in electrical activity in the brain during compassion meditation concordant with the expertise of the practitioner and with self-reported depth of meditative state achieved in a session.

During the experiments results were compared among the following categories of subject volunteers:
Novices : Volunteers who are interested in meditation but do not have experience
Experts : who had an average of 19,000 practice hours of meditation behind them
Masters : experts with about 44,000 hours of meditation practice *(the term 'master' was not used in the original report, 'experts with 44,000 hrs' was used instead)*

Trainability (Learning Curve)

In FA meditation it was noted that experts with 19,000 hours practice showed stronger activation of some brain areas than novices while the masters displayed less activation (inverted U). This pattern resembles the effort mapping in the 'learning curve' associated with skill acquisition in other domains of expertise, showing that after training, minimal effort is required to sustain attention.

Processing Speed

Open Monitoring [OM] meditation decreases elaborative stimulus processing. Thus experts are better able to attend to a fresh stimulus very soon after the previous one. When a rapid stream of events is presented to a novice a second target is often missed. The two targets would be competing for attention, and with limited attentional resources (Slagter, Lutz et al 2007 *PLoS Biol*), one event may consume attention leaving inadequate resources for the next event. You may have observed experts in other domains taking on and handling varied challenging tasks in quick succession, giving each case the benefit of quality attention and analysis, e.g a doctor in a busy OPD, or an official dispensing numerous files in one sitting. Novices look up to them and wonder how they do it without getting perturbed.

Changes in Baseline State

On EEG high amplitude pattern of gamma synchrony is observed as self induced in expert meditators during compassion meditation (an emotional version of OM) along with long-distance phase synchrony over lateral fronto-parietal electrodes (Lutz

Lawrence et al 2004 *Proc Natl Acad Sci*). The precise mechanisms behind this observation are not yet clear, but may play a role in the formation of transient networks that integrate far-flung neural processes into ordered cognitive functions. Most significantly the experts displayed pronounced gamma synchrony in the baseline state, suggesting a permanent alteration in neural dynamics. In other words training changes the brain.

Thickness of cortex

When we learn a new activity we bring into use existing networks that may not have been synchronously used before. When learning how to drive we often find it difficult to press down the right and left foot independently, or while playing a musical instrument, we find it strange that the right and left hand have to perform different movements. After sufficient hours of practice we find ourselves doing better. That is when neurons that fire together begin to stick together at the synapses. Soon the activity takes less and less effort. While performing effortlessly a 'flow' state can be achieved, this is joyful and self-rewarding. This experience of achievement motivates the practitioner to raise the bar and achieve further to gain mastery. The masters have permanent neuroplastic changes in their brain as well as enhancement in all the muscles and nerves that participate in the process. Thus a sportsperson is not merely building muscle, but a whole circuitry involving innumerable neurons. Dedication in any field with practice and focused attention will result in monk-like base-line calmness and lower emotional reactivity.

Regular practice of meditation results in increased thickness of cortical areas (Lazar et al 2005 *Neuroreport*) notably the right insula and pre-frontal cortex. These brain regions are the seat of the following functions:

Pre Frontal Cortex:
Planning complex cognitive behaviors,
Personality expression,
Decision making
Moderating appropriate social behavior
Delaying gratification
Emotional regulation

Insula :
Awareness of body state
Sense of Self
Integration of emotion and cognition
Perception of exertion
Judgment of degree of pain
Contributes to eye and hand movement
Affects some autonomous control mechanisms (e.g. heart rate and BP in response to exertion)
Processes disgust and other emotions

Processes norm violations
Empathy
Affects conditioned immune responses

In all body tissues (and brain is a tissue) use and reuse vitalizes, nurtures and results in robustness of health and function as well as growth. Disuse and idleness leads to wasting and pruning.

Fitness leads to Confidence

Any tissue or organ that is robust and vitalized by repeated use is fit to perform its specific tasks when challenged. Healthy brain tissue indicates potential. When challenged by real life situations a person who has developed mastery in a field can be expected to perform well. Mastery in practice sessions boosts confidence levels and raises the threshold for threat perception.

Studies have shown that meditation could revert age-related thinning of the pre-frontal cortex and maintain health and cognition and social effectiveness in the elderly.

Meditation, or other attention focusing activities and those that help to practice alertness when practiced over long hours help nurture the same tissues that participate in socially effective living, notably empathy, self-awareness, decision making after processing complex inputs, emotional regulation and insight. These competencies are the very abilities laid out on the Emotional Competency Framework (Daniel Goleman), that contribute to 'getting along with others' effective leadership, teamwork, relationship building and to success. Robustness of these brain tissues facilitates the use of emotional intelligence and social intelligence.

Studies have demonstrated that emotions can be voluntarily invoked and the effects can be recorded in the laboratory (Lutz et al 2008 *PloS*). Turning around negative emotions to positive ones is a trainable skill and such training can be advocated for management of various emotionally labile conditions as well as for attention deficit disorders.

Relation to Stress

Meditation calms the mind and reduces distractions. This serves to soothe the HPA Axis (Hypothalamo-Pituitary-Adrenal Axis) reducing the circulating levels of stress hormone cortisol. Mirescu and Gould's later experiments have proved that high cortisol levels suppress neurogenesis. New neurons as we know now must take birth and plug into existing neural networks in order to thrive. This precious process is essential to learning, training, creativity and maintaining the robustness of the brain, and is compromised during stress. The earlier we climb out of the vortex of stress; we can prevent deterioration of body tissues, especially the brain. Meditation is a voluntary technique to achieve this (Mac Lean et al 1997 *Psychoneuroendocrinology*).

Effects on the Immune System

Other studies on meditation and the immune system have demonstrated that mindfulness based stress reduction intervention of eight weeks led to changes in the brain the magnitude of which predicted the magnitude of antibody titer response to an influenza vaccine (Davidson et al 2003 *Psychosom Med*). Another study by Rozenkranz showed that some of the same brain circuits affected by meditation are those implicated in modulating inflammatory processes in the lung in asthmatics (Rosenkranz et al 2005 *Proc Natl Acad Sci*). Thus meditative techniques can work as a voluntary handle to intervene in immune processes as well as prepare the brain to respond to experience through constructive neuroplasticity.

Executive Functions of Brain

By becoming increasingly more aware of sensory stimuli during formal practice the meditator is able to use this self awareness to successfully navigate through potentially stressful encounters through the day. The tissue that plays a star role in the process of dealing with real life is the copious connection between the sensory cortices and the emotional cortices. This strap of tissue lies on the roof of the orbit (eye) called the orbito-frontal cortex [OFC] and participates in processing of emotionally salient material and adaptive decision making (Damasio). The OFC functions as a pair of reins in the hands of the cognitive brain to regulate the emotional mid-brain. Regular use by moderating impulses, delaying gratification, delaying reaction, adapting to unfamiliar conditions, acceptance of situations that are outside one's control, conscious mood alteration, are ways to develop this crucial band of nerve connections. Damage or disease in this region results in a syndrome of personality change, social maladjustment and paralyzing indecisiveness as encountered in the classic case of Phineas Gage and Damasio's patient Eliot.

Practitioners of meditation benefit from a heavier pre-frontal cortex and a robust OFC that connects the PFC with the emotionally excitable mid-brain, creating an effective 'pause button' to prevent reacting from the amygdala and giving the cognitive brain the crucial fraction of a second long pause to consider alternative responses and to choose the best one for the situation. That's Emotional Intelligence!

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