Neurological Research on Meditation

Knowledge of the neurophysiology of meditation. including mindfulness, is changing rapidly. Recent advances in medical imaging, such as rCBF (regional Cerebral Blood Flow), real time MRI (Magnetic Resonance Imaging), MEG (magnetoencephalography), and improved EEG (electoencephalography) allow detailed studies that are reshaping our understanding of the effects of meditation on neural behavior. Already there are several basic effects that have been documented which demonstrate the profound influence meditation has on neurophysiology. For example, in reviews of the literature on meditation research, published in 2006, and more specifically on mindfulness research published in 2009, the writers concluded that the three substantiated neurological effects of meditation at this time are 1) an increase in Alpha and Theta brainwave activity, 2) changes in both the prefrontal cortex (PFC) and the anterior cingulate cortex (ACC) and 3) changes in cerebral areas related to attention. Chiesa A, Serretti A (2009). "*A systematic review of neurobiological and clinical features of mindfulness meditations.*" *Psychol Med* 40(8): 1239-52. Epub 2009 Nov 27.

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Dr. Newberg found that the front part of the brain, which is usually involved in focusing attention and concentration, is more active during meditation, but there was greatly decreased activity in the parietal lobe. See his research results, see the article "The Effect of Meditation on the Brain activity in Tibetan Meditators" on Dr. Newberg's website. (Unfortunately the specific type of meditation is not identified.)

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The Youtube video at this link offers an introduction to this topic by Dr. Newberg, describing the similar neurological research results across spiritual traditions, the difference in the brains of experienced practitioners and those who don't practice, as well as the "chicken vs the egg" issue this difference raises.

Neuroimaging has been used to study meditation from other angles, including the comparison of the impact of different forms of meditation on the activation of particular brain regions, neurophysiological differences between novice and experienced meditators, and the relationship between particular subjective meditative states and neuroanatomy, and the effects of long-term meditation practice on brain size. One study used fMRI to study the Japanese monks doing two somewhat similar meditation practices: reciting a mantra and reciting a Buddhist sutra. These two practices both cause increased activation in the cerebral cortex though in different folds of the cerebral brain matter. The mantra activated areas associated with concentration and visuo-spatial attention while sutra recitation affected only regions known to be involved in visuo-spatial attention, albeit different such regions than were activated by mantra practice. (Shimomura T, Fujiki M, Akiyoshi J, Yoshida T, Tabata M, Kabasawa H, Kobayashi H (2008) Functional brain mapping during recitation of Buddhist scriptures and repetition of the Namu Amida Butsu: A study in experienced Japanese monks. *Turk Neurosurg 1*8(2): 134-41.)

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Neuroimaging (MRI) has identified a particular set of brain regions, the default network, that activate when we rest wakefully but then shut down when we resume activity. These regions have been associated with the 'stream of consciousness' thinking that tends to arise when we are in a waking resting state. Zen practice is known to be a waking restful state, which however for experienced practitioners involves less 'stream of consciousness' thinking. Neuroimaging research on Zen practitioners showed a shorter duration of response in the default network. The researchers propose that "that meditative training may foster the ability to control the automatic cascade of semantic associations triggered by a stimulus and, by extension, to voluntarily regulate the flow of spontaneous mentation." (Pagnoni G, Cekic M, Guo Y (2008). Thinking about not-thinking: neural correlates of conceptual processing during Zen meditation.*PLoS One* 3(9): e3083.

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Neurochemical Effects

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In a Scandinavian research project, Acem Meditation, which the researchers describe as being similar to Transcendental Meditation in that it involves the repetition of a sound or mantra, has also been associated with increased melatonin availability. Melatonin is also an important neurotransmitter and neuropeptide that influences mood and behavior. It is derived from serotonin. Melatonin has been linked to regulation of sleep. Solberg EE, Holen A, Ekeberg Ø, Østerud B, Halvorsen R, Sandvik L (2004). The effects of long meditation on plasma melatonin and blood serotonin. Med Sci Monit. 2004 Mar;10(3):CR96-101

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Working with long-term qigong meditators vs. a control group, Tei, et al., studied EEG profiles during a resting state. The differences between the two groups led them to conclude that:

> "In the meditators, (in contrast to the control group) appraisal systems were inhibited, while brain areas involved in the detection and integration of internal and external sensory information showed increased activation. This suggests that neuroplasticity effects of long-term meditation practice, subjectively described as increased awareness and greater detachment, are carried over into non-meditating states." Tei S, Faber PL, Lehmann D, Tsujiuchi T, Kumano H, Pascual-Marqui RD, Gianotti LR, Kochi K (2009). Meditators and non-meditators: EEG source imaging during resting. *Brain Topogr* 22(3): 158-65. Epub 2009 Aug 4.

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Clinical Implications

Two reviews of the literature explore clinical implications. The Rubia review summarizes that,

> "Physiological evidence shows a reduction with meditation of stress-related autonomic and endocrine measures, while neuroimaging studies demonstrate the functional up-regulation of brain regions of affect regulation and attention control. Clinical studies show some evidence for the effectiveness of meditation in disorders of affect, anxiety and attention." Rubia K (2009). The neurobiology of Meditation and its clinical effectiveness in psychiatric disorders.*Biol Psychol* 82(1): 1-11. Epub 2009 Apr 23.

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Conclusion

The neurological study of meditation is still very much in its infancy. While its promise is great, there are many challenging issues to address to harness these findings. In their survey of the research relative to the impact of meditation on cognition and brain plasticity , Xiong and Doraiswamy offer the following assessment of the tasks that lay ahead:

> "The enthusiasm [for the positive results of neurological research on meditation to date] must be balanced by the inconsistency and preliminary nature of existing studies as well as the fact that meditation comprises a heterogeneous group of practices. Key future challenges include the isolation of a potential common elements in the different meditation modalities, replication of existing findings in larger randomized trials, determining the correct "dose," studying whether findings from expert practitioners are generalizable to a wider population, and better control of the confounding genetic, dietary and lifestyle influences." Xiong GL, Doraiswamy PM (2009). "Does meditation enhance cognition and brain plasticity?" Ann N Y Acad Sci 1172: 63-9.

As such, an important next step relative to mindfulness is to specifically research the neurophysiology of this kind of meditation practice.

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