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 (electroencephalography) 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.)

The parietal area of the brain is responsible for giving us a sense of our orientation in space and time. He hypothesized that blocking all sensory and cognitive input into this area during meditation results in the sense of no space and no time. When this part of the brain, which weaves sensory data into a feeling of where the self ends, is deprived of sensory input through the meditator's focus on inward concentration, it cannot do it's job of finding the border between the self and the world. Dr. Newberg described how this affects consciousness:

“The brain had no choice. It perceived the self to be endless, as one with all of creation. And this felt utterly real. The absorption of the self into something larger [is] not the result of emotional fabrication or wishful thinking. It springs from neurological events, as when the orientation area goes dark.” Why God Won't Go Away: Brain Science and the Biology of Belief by Andrew Newberg M.D.

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, although 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 18(2): 134-41.)

Using fMRI to study the impact of concentration forms of meditation practice, where the intent of the practice is to train the mind to stay focused on a single object of attention, on brain activity, activation of a network of brain areas typically involved in attention was increased for meditators with an average of 19,000 hours practice as compared with novices. However more experienced meditators, averaging 44,000 hours practice showed less activation of the same region. The researchers suggest that this can be understood as moderately experienced group having better skill at the effort required to establish and sustain attention than the control groups while the most experienced meditators had so mastered the concentration skills involved that very little effort was required. (Brefczynski-Lewis JA, Lutz A, Schaefer HS, Levinson DB, Davidson RJ. (2007). Neural correlates of attentional expertise in long-term meditation practitioners. Proc Natl Acad Sci U S A 104(27): 11483-8. Epub 2007 Jun 27.)

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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 O, Österud 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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“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

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Conclusion

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“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 NY 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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