

This Is Your Brain on Mindfulness



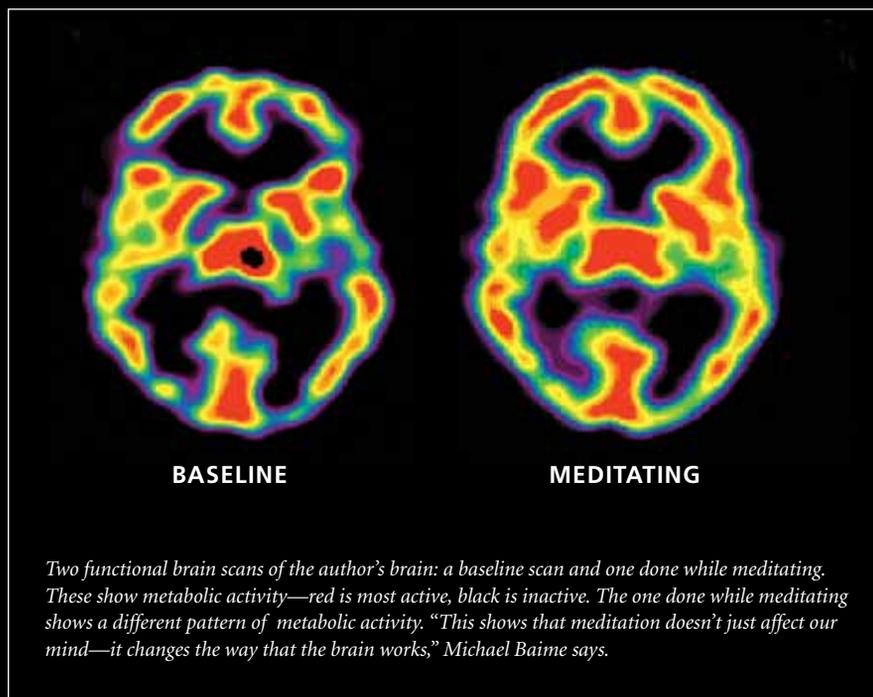
Meditators say their practice fundamentally changes the way they experience life. MICHAEL BAIME reports on how modern neuroscience is explaining this in biological terms.

MEDITATORS FIND TRUTH through carefully exploring their inner subjective experience in what some people like to call “first-person investigation.” Science looks to the external material world and relies on third-person investigation and methodologies that lead to discoveries that can be tested and replicated by peers in the scientific world. The ways that these traditions search for truth couldn’t be more different, and yet it shouldn’t surprise us to find that the two truths are actually one.

Nevertheless, scientists have traditionally viewed meditators’ assertions with a healthy skepticism, and meditators have often felt the same way about scientists’ requirement for objective proof of meditation’s benefits. More recently, however there has been an explosion of both popular and scientific interest in the biology and neuroscience of meditation. The National Institutes of Health has funded



DR. MICHAEL BAIME is clinical associate professor of medicine at the University of Pennsylvania, and is based at the Abramson Cancer Center in Philadelphia. He founded the Penn Program for Mindfulness in 1992 and is involved in a wide variety of projects exploring the effects of mindfulness and similar practices.



Two functional brain scans of the author’s brain: a baseline scan and one done while meditating. These show metabolic activity—red is most active, black is inactive. The one done while meditating shows a different pattern of metabolic activity. “This shows that meditation doesn’t just affect our mind—it changes the way that the brain works,” Michael Baime says.



PHOTO BY DANIEL ONTANEDA

Neuroscientists Amishi Jha of the University of Pennsylvania, and Britta Hölzel and Sara Lazar of the psychiatry department at Massachusetts General Hospital.

numerous research projects to explore the effects of meditation; ongoing investigations are exploring the role of meditation and mindfulness on health and healing; and neuroscientists have recorded brain waves and made pictures of brain activity in many thousands of meditators, ranging from novices in urban practice centers to monks in the secluded monasteries of Tibet.

There is no question that you can become a perfectly good meditator without any complicated neuroimaging technology. On the other hand, for those of us who are interested in practicing mindfulness and other related forms of meditation, the modern science of meditation offers us a window into some very interesting—and important—areas of our practice and our lives. Can the benefits meditators say they experience—increased calm, decreased stress, better attention, and so forth—be traced to actual neural changes?

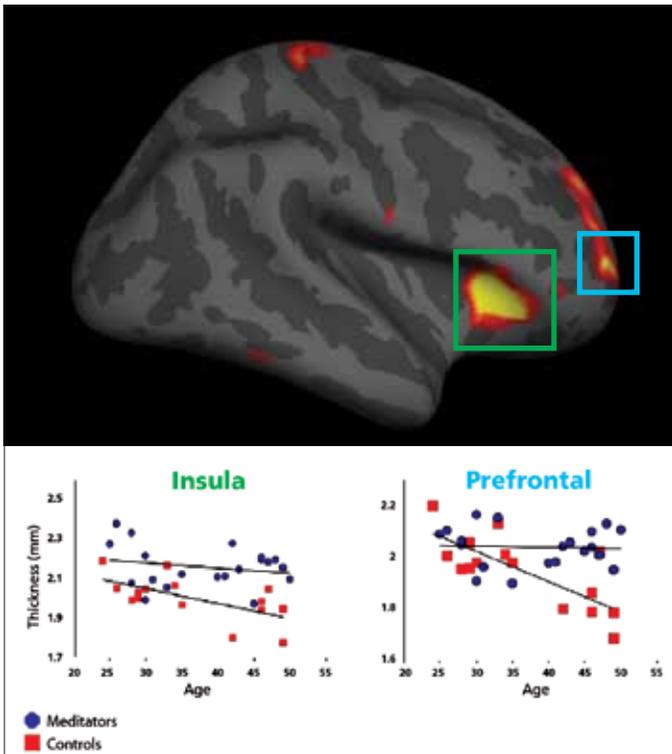
Scientific studies have found increasingly concrete proof of the inseparability of body and mind, and have even given us a glimpse of the biological basis of the illusion of self.

In the last several decades, the scientific study of meditation has provided increasingly concrete proof of the inseparability of body and mind. It has also demonstrated ways we can literally change ourselves and our world through practice; shown us the observable changes in the systems and subsystems that govern our attention as we progress from the focus of mindfulness to the panorama of awareness; and even given us a glimpse of the biological basis of the illusion of the self.

CHANGES IN REGIONS OF THE BRAIN

One of the most interesting areas of research on the effects of contemplative practices has explored the possibility that the actual structure of the brain is changed by meditation practice. Several neuroscientists have shown that some of the brain regions activated during meditation are actually different in people who meditate regularly, and the most recent evidence suggests that the changes can occur in as little as eight weeks. This finding is at odds with what we think we know about brain structure in adults. We used to believe that sometime shortly after twenty-five or thirty years of age the brain was finished with growth and development. From then on, the brain became progressively impaired by age and injury, and it was all downhill from there. But recent meditation research suggests that this glum outcome may not be inevitable. Meditation practice is associated with changes of specific brain areas that are essential for attention, learning, and the regulation of emotion.

Maybe this shouldn't be such a surprise. When you exercise your muscles in the gym, they become larger as well as stronger. Their structure changes. In fact, almost any structure of the body changes

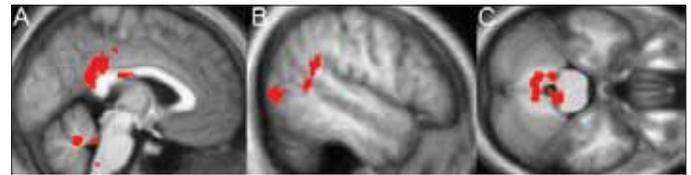


Cortical areas are thicker in meditators. Image © Sara Lazar.

when it is used more often. It now seems that this is also true for the brain. For instance, we know that when you learn to juggle, the part of the brain involved with tracking objects in space becomes larger. Meditation shouldn't be any different. Like all cutting-edge research, this work on brain size is controversial, but it has already become an area for deeper investigation by more researchers.

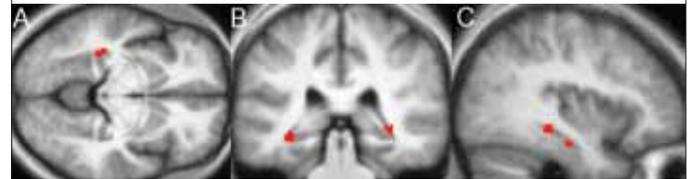
The first researcher to report the effect of meditation on brain structure was Harvard neuroscientist Sara Lazar, a researcher in the psychiatry department at Massachusetts General Hospital. She performed magnetic resonance imaging (MRI) to obtain highly detailed pictures of the brains of twenty meditators recruited from meditation practice centers near Boston, and compared them with images obtained from a control group of twenty nonmeditators. The meditators were experienced practitioners, but they were not monks, nuns, or full-time retreatants. They had practiced for an average of about nine years, and spent, on average, a little less than an hour a day meditating. All were Westerners, living in the United States and working in typical jobs. The nonmeditators were local volunteers, matched to the meditators for characteristics like age and gender, but with no experience in yoga or meditation.

Lazar was looking at the brain's cortex—the outermost surface of the brain. This is the most evolutionarily recent part of the brain. When the brain images of the two groups were compared, she found that some cortical areas in the brains of the meditators were significantly thicker than the same areas in nonmeditators. The cortex atrophies with age; in Lazar's meditating subjects, however, these enlarged areas were the same thickness as what was measured in nonpractitioners twenty years younger.



Areas that showed increase in gray matter concentration following eight weeks of mindfulness-based stress reduction.

- A: posterior cingulate cortex and cerebellum,
- B: temporo-parietal junction,
- C: cerebellum and brain stem.



Brain scans of the hippocampus, showing the regions that were affected by meditation.

Images adapted from Britta Hölzel, et al., *Psychiatry Research: Neuroimaging* Vol. 191 (1), January 30, 2011, pp. 36-43.

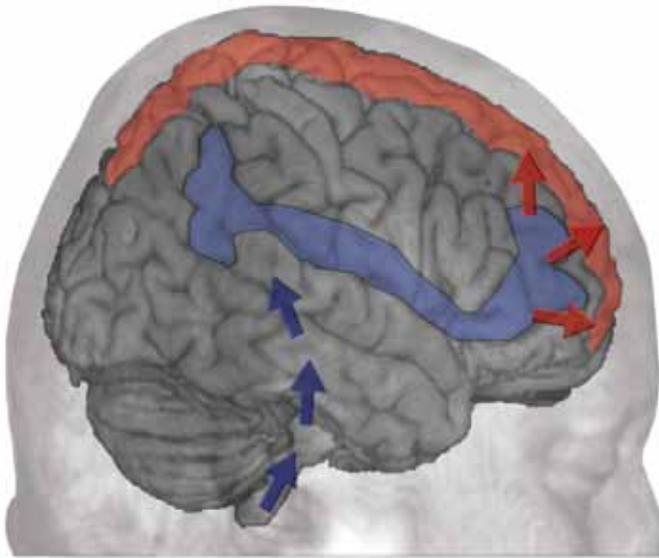
Images © Britta Hölzel.

Previous work had already shown that these areas were more active during meditation practice. One of the areas was in the prefrontal cortex, the part of the brain that is farthest forward inside the skull, closest to the forehead. The other area identified by Lazar was in a different region of the cortex called the insula.

Although it is extremely difficult to isolate a specific mental function to a particular brain region (and the results of efforts to do so are controversial in the scientific community), the particular areas that Lazar identified in the frontal cortex are essential for a variety of critically important capabilities. The prefrontal cortex manages higher cognitive “executive” functions like planning, decision making, and judgment, and keeps us out of trouble by facilitating socially appropriate behavior. It allows us to hold two concepts or experiences in mind simultaneously so that we can compare and evaluate plans, ideas, and memories. It also helps us to link memory with sensory input so we can connect what we have learned from the past with what is happening in the present moment.

The other major region identified by Lazar, the insula, seems to integrate sensation and emotion, and to process social emotions—such as empathy and love. It is thought to be essential for the capacity for self-awareness. Although no region of the brain is unimportant, the activities supported by these brain areas are especially crucial for our effective functioning in the world.

This research is still viewed as preliminary, partly because it contradicts a lot of what we thought we knew, and partly because it studied only twenty meditators. Lazar says that among her scientific peers, some are enthusiastic while others are skeptical. Subsequently, however, Lazar's work was confirmed by a researcher in



Sensation flows from our body into brain regions associated with present-moment awareness (blue), often activating a connected set of brain regions associated with descriptions, narratives, and evaluations (red). Mindfulness training appears to weaken this body/narrative association. Image © Norman Farb.

seen after only eight weeks of practice in a Mindfulness-Based Stress Reduction program.

Hölzel says her neuroscience research has been extremely helpful in her own mindfulness practice. “It helps me to refine my practice, to be more aware of the processes that are going on while I’m practicing,” Hölzel says. “It also helps me to cultivate patience and acceptance. You might think that it should be easy to quiet your mind, but I know that neural systems take time to change, and wandering is built into the system. That knowledge allows me to accept how it is right now for me. It’s not my fault or my problem. It is simply the way that the brain is built and how the system functions.”

The benefit of this information for practitioners is confirmed by Lazar. “The thing that surprised me most about this research,” Lazar says, “is how many senior practitioners and meditation teachers say that it motivates them to practice during the times when their meditation seems to be going nowhere.” She says meditators often tell her, “I used to think that I was wasting my time because my mind was all over the place. This helps to keep me on the cushion because I remember how significant these changes are.”

The most recent research suggests that a regular meditation practice can cause beneficial structural changes in the brain in as little as eight weeks.

Germany, Britta Hölzel, who also found additional regions, hidden more deeply within the brain, that had increased gray matter density in meditators. Gray matter is the part of the brain that holds most of the actual brain cells; its increased density may reflect an increase in connectivity between the cells. Hölzel, who is a meditation practitioner as well as a researcher, now works with Lazar in Boston. The regions that Hölzel and Lazar identified are areas that are associated with the kinds of psychological and behavioral changes reported by meditators for millennia.

One of these regions allows us to shift perspective, an ability that supports a variety of skills and behaviors, including empathy (when we take the perspective of another) and the management of emotional upheavals (when we step out of our reactivity). This is completely in keeping with what actually happens during mindfulness practice. The shift of perspective from automatic-pilot reactivity to a more aware and observant witness is a central component of meditation training. Over and over, you practice shifting from a dreamy nonawareness into the vividness of the present moment. Lazar and Hölzel have also recently reported that the region of the brain most associated with emotional reactivity and fear—the amygdala—has decreased gray matter density in meditators who experience less stress. The most surprising finding was that both of these types of structural brain changes were

INCREASED ATTENTION

Another area of recent research on the effects of meditation deals with the role of meditation in enhancing attentional performance. Whether our practice focuses on the breath, a sound, or a thought (for instance, a repeated phrase or a visualized image), attention is always central to meditation. That may seem ironic, because there is nothing like a long meditation session to demonstrate how difficult it is to control the attention. Countless distractions arise, seemingly out of nowhere, and hijack our awareness despite our best intentions. Especially if you are relatively new to meditation, you might think your practice is actually making you more distracted. Research, however, has shown that the distractions are actually less common, but that with practice you are more likely to notice them because your attention works better. You notice more of everything, including wandering and distractedness. Laboratory testing can measure exactly how the mind becomes stronger with practice, and it demonstrates significant improvements over a relatively brief period of time.

Amishi Jha is a pioneer in this area of investigation. She has applied sophisticated computer-based testing to measure attentional performance in meditators. Jha performed this type of testing on a group of medical and nursing students at the University

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The Science of Meditation

The Mind & Life Institute, reports ANDREA MILLER, explores the intersection of ancient meditative disciplines and modern science.

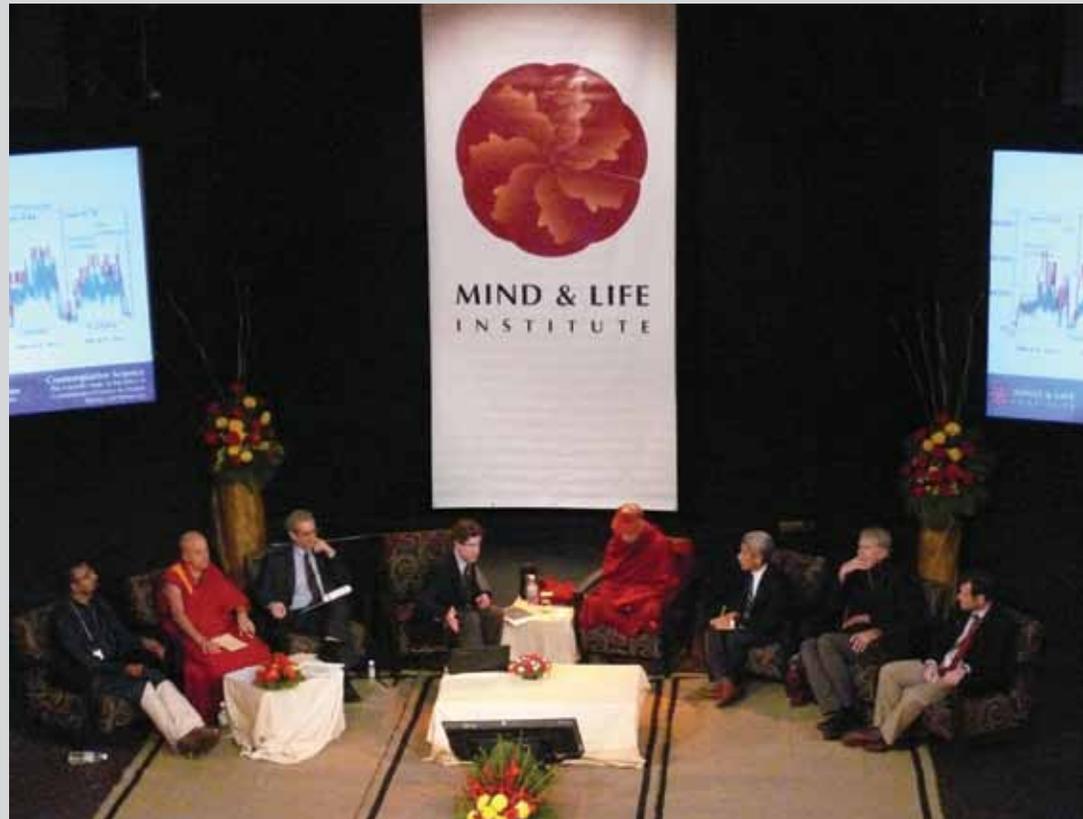
THERE IS NO CONTRADICTION between science and spirituality because “each gives us valuable insights into the other,” says His Holiness the Dalai Lama. “With the ever-growing impact of science on our lives, religion and spirituality have a greater role to play by reminding us of our humanity.”

The Mind & Life Institute, founded by the Dalai Lama, entrepreneur Adam Engle, and the late neuroscientist and philosopher Francisco Varela, is a pioneering nonprofit organization that brings together scientists and contemplatives for the purpose of understanding the nature of reality, and ultimately creating a healthier, more balanced society.

The first Mind & Life conference was held in 1987 in Dharamsala, India. It was structured as a five-day dialogue between Buddhists and specialists in cognitive sciences, and was attended by the Dalai Lama, six scientists, two interpreters, and a few observers. Since then, Mind and Life has convened twenty-two conferences, some by invitation only, others large public events. About three thousand people participated in the 2005 conference in Washington, D.C., which focused on the scientific and clinical applications of meditation.

In addition to its landmark conferences, Mind & Life has research initiatives. Notable among them is the Mind and Life Summer Research Institute (MLSRI), an annual weeklong program held at the Garrison Institute in Garrison, New York. At once a retreat and a scientific conference, MLSRI encourages collaboration among behavioral scientists, neuroscientists, biomedical researchers, and practitioners and scholars of the contemplative traditions, and features presentations by some of the most progressive thinkers in those fields. Since 2004, more than 1,000 faculty and participants have attended through competitive application.

MLSRI's long-term objective is to advance the training of a new generation of scientists and contemplative scholar-practitioners.



Mind & Life Conference with the Dalai Lama in New Delhi, India, 2010.

Research fellows participating in the summer conference have the opportunity to present studies they've conducted, and, afterward, may apply for the Mind & Life Francisco J. Varela Research Awards. So far, Mind & Life has distributed \$1,175,000 dollars in funding to support emerging scientists. The research areas of recipients have included mindful awareness practices for preschool children to improve attention and emotion regulation; the effects of mind-body interventions in supportive care for people with cancer; and mindfulness training as both a way of treating drug addicts and investigating the mechanisms involved in addiction.

The theme of Mind & Life's 2011 Summer Research Institute, being held at Garrison from June 12 to 18, is “New Frontiers in the Contemplative Sciences.” The focus is on unresolved challenges for the advancement of contemplative neuroscience, contemplative clinical science, and contemplative studies in light of the progress made since MLSRI's inception. ♦

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of Pennsylvania in Philadelphia before and after an eight-week mindfulness-based training course. The class was designed to teach students to use meditation to manage stress, enhance communication, and cultivate empathy. (I also worked on this research and designed and taught the meditation course.)

After only eight weeks of training, testing revealed that the students who were taught to meditate could intentionally direct and focus their attention more quickly than a matched group of untrained students. Another study used similar tests to investigate the effects of a monthlong intensive group meditation retreat at Shambhala Mountain Center in Colorado. These participants had considerably more practice experience than the students, and practiced for eight to ten hours each day during the retreat.

Interestingly, the more experienced retreat participants did not demonstrate the increase in capacity to direct and focus attention that was seen in the novice meditators; they were pretty good at that when the retreat started. Instead, the retreat participants had a change in the nature of their attention. Their awareness became much more open and alert. This finding seems to describe the transition from focused mindfulness to broader and deeper insight and awareness described in traditional meditation teachings. As expected, the retreat participants also had substantially less mental wandering, and more insight into wandering and distraction when it occurred.

Other testing from Jha's lab has demonstrated that meditation improves working (or short-term) memory as well as the ability to resist distraction. This has very significant implications for improving our ability to accomplish our goals in everyday life. She has found that even very short periods of regular practice, as little as twelve minutes a day, are associated with significant improvements in working memory. More practice is associated with better results, including both improved accuracy and reduced wandering.

A DIFFERENT EXPERIENCE OF THE SELF

Another recent stream of research on meditation has explored the way that practice affects the experience of the self. One recent set of reports from the University of Toronto explores the way meditation affects the way we construct a self out of our experience and the relationship between the narration we use to create a self and our direct moment-to-moment experience. Two distinct neural networks in different parts of the brain contribute to our experience of a "self." Activity in one region is associated with a descriptive narrative: thoughts *about* what is happening and how we are. The other region is associated with a more direct experience of sensation and emotion in the present moment.

The two areas are linked so that activity in the "present-moment" awareness region activates the storytelling region. So a shift away from more direct sensory awareness into thinking is not just random; it is literally built into the nervous system. This might explain why the experience of nonconceptual mindfulness and awareness is often so fleeting. A moment of nonthought jump-

starts the storytelling areas of the brain.

In the study, participants were asked to employ different types of focus, corresponding to the two distinct modes of self-reference. "Narrative focus" calls for elaborating mental constructs within our minds, weaving a story as it were, which reduces attention toward sensory objects available in our immediate experience. By contrast, "experiential focus" calls for inhibiting our elaboration on any given mental event in favor of broadly attending to the objects in our experience and "canvassing thoughts, feelings, and physical sensations without selecting any one sensory object."

Narrative focus is associated with ruminative thoughts about the self, while experiential focus avoids rumination. It disengages the brain networks that lead to self-referential story-making. The researchers noted that while a focus that centers on experience in the present includes a strong component of paying attention to bodily sensations, meditation practice is associated with developing moment-to-moment awareness of *all* available stimuli. Accordingly, when participants were instructed to maintain an experiential focus, they were encouraged to include "internal thoughts, emotions, and external sensory events, in addition to bodily sensations." A mindfulness-trained group was compared with a novice group in how they performed in working with these different types of focus and, by extension, the two different neural regions: the one associated with story-making about the self and the other associated with immediate experience.

The Toronto group demonstrated that meditation practice enhances the ability to disconnect these two regions and engage more robustly in experiential focus. As a result, the likelihood that an experience of present-moment awareness will automatically be followed by a self-centered monologue is reduced. Even the habitual patterns that are deeply built into the body can be changed with practice. Norman Farb, the lead investigator of the study, says that the work demonstrates how "mindfulness changes the very ground of the way that we experience the self." ♦