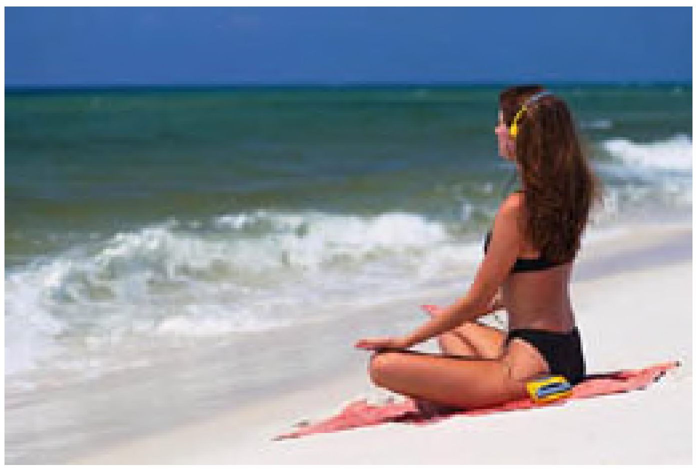
You Can Change Your Mind

Meditation's Beneficial Neurological Effect on the Brain

December 17, 2004

by Elena Greco



(image courtesy
http://www.virtualcs.com/meditat/lesson1.html)

Please note that the author supports the rights of animals and does not support animal torture in the pursuit of science, and has therefore refrained from knowingly utilizing any studies or experiments that involved the restraint or torture of animals.

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With the advent of exciting neurological imaging techniques in the last two decades, a whole new world has opened to us. We can see what actually happens to our brain during meditation. With this new and amazing information comes the reality that we truly <u>can</u> change our mind. Don't like your mood? Meditate. Want to stem your aggression? Meditate. Have a desire for a superbly-functioning nervous system and a highly-charged intellect? Meditate. Now we can see how—and why—all of these things take place. And the results tell us one thing: Meditate. It's good for you!

We know that our happiness is not determined by our circumstances. Look around—aren't there people who have very difficult circumstances who are always cheerful? And aren't there people who have lives that look great from the outside, but who are always depressed, angry, pessimistic or grumpy? There are many factors that might contribute to the difference in mental state, but thanks to the recent developments in medical imaging technology, we know now that there is a very distinct difference in the brains of folks who are cheerful and relaxed and those who are not. And, conversely, it seems that altering that difference in neurophysiology also alters our outlook. The means of doing that is a natural technique that anyone can learn and practice absolutely for free.

Scientists have recently learned that meditation shifts our EEG waves toward alpha or theta, it affects our autonomic nervous system positively, and, possibly most importantly, it shifts activity from the right temporal lobe to the left temporal lobe, all of which combine to result in a positive mood, less aggression, a more relaxed state, a healthier immune and neurological systems, a slowing of the aging process, and ultimately a feeling of compassion which results in still further brain changes. In short, it renders us happier, healthier human beings who are in a better condition to contribute to society.

What Is Meditation?

The practice of meditation is thousands of years old. It is the foundation of many far-eastern spiritual practices and philosophies. Both Hinduism and Buddhism consist of many different sects and practices, and the one thing that almost all of them have in common is a system for practicing meditation that originated thousands of years ago and continues today.

When studying the neuroscience of meditation, it becomes important to define what exactly we mean. Is meditation the act of practicing the techniques of meditation? Or is it the state that happens as a result of practicing these techniques? Some types of meditation are geared toward developing spiritual qualities or attaining religious goals, while other forms strive to improve our mind and actions, without any specific spiritual overtones. Also, meditation goes by many names: for example, zazen, kundalini yoga meditation, Transcendental Meditation® and mindfulness meditation, to name just a few. However, there are certain elements that all meditation practices have in common, and the effects on neurological functioning of the practice of these elements, regardless of the name of the practice studied, will be the focus of this paper.

Researchers in Japan offered a definition for meditation in the study of neuroscience that includes the "attainment of a restful yet fully alert physical and mental state" (Takahashi, 2004); this definition seems to refer to a desired outcome of the practice of meditation rather than the elements used to attain it or practice it. Researchers at the University of São Paolo, pointing out that there is no standard definition in the scientific world for "meditation," proposed that it be required to have specific characteristics in order to be considered "meditation" for scientific studies, which include a clearly-defined technique, relaxation of body and mind, that it be self-induced (i.e., not guided by someone else, as in visualization or hypnosis) and that it include a focusing technique (e.g., focusing on a mantra or watching thoughts) (Cardoso, 2004). We will examine in this paper the neurological effects of using a *clearly-defined, self-induced practice that utilizes a specific technique to focus the mind*.

How We Can See the Neurological Effects of Meditation

We now have six primary imaging methods for examining the activity in the brain: EEG, MRI, fMRI, CAT, PET and SPECT. The first three, EEG, MRI and fMRI, are non-invasive, while the last three, CAT, PET and SPECT, usually involve the injection of a radioactive substance, something many meditators are not willing to risk. However, there are some individuals who have offered themselves as subjects and submitted to this so that the rest of us can learn of the effects of meditation on the brain. As a result, we already have a number of studies that have given us valuable data.

EEG (electroencephalogram) is a method of measuring brain waves electronically. After attaching electrodes to the subject's head, the electrical activity at various points in the head is recorded by a device connected to the electrodes. This is not a new technique, but scientists are using it in ways that they have not previously—for example, in studying brain waves during meditation. The EEG has been useful in the past for determining seizure activity and studying sleep. It can determine the frequency and amplitude of brain waves, so that we can determine which type of brain wave is being produced. This information is useful when studying the effects of different stimuli on the brain.

MRI (magnetic resonance imaging) zaps the brain with a strong magnetic field and uses sensors around the head to detect electromagnetic signals generated by the hydrogen atoms in response to this magnetic field, then converts this into an image. It uses no radiation, and can produce a very detailed image of any area of the brain. Its limitation is that it works best to show physical changes in the brain, rather than chemical or metabolic ones, and that the enclosed capsule in which it is performed makes it a difficult experience for those with claustrophobia.

fMRI (functional magnetic resonance imaging) quantifies changes in blood flow and metabolism. Active neurons require more fuel, causing blood flow to increase in active areas of the brain, so fMRI can determine where in the brain vascular activity increases in various circumstances. It is similar to the MRI, but uses chemical data to analyze the image, rather than just physical data. Using the MRI or the fMRI is somewhat difficult for testing meditation because of the noise produced by the machine and the requirement that the subject be lying on his or her back, which sometimes feels unnatural for meditators, who are usually accustomed to meditating in a seated posture.

CAT (computed tomography) shows us a slice of the brain. An X-ray is shot through the brain on one side, while a sensor on the other side of the brain records how much radiation made it through each area (radiopacity). Areas that absorb a lot of radiation show in the scan as a different color from those areas that don't absorb a lot of radiation. This allows a good view of the slice of brain without surgery. The drawback to the CAT scan is the fairly large exposure to radiation.

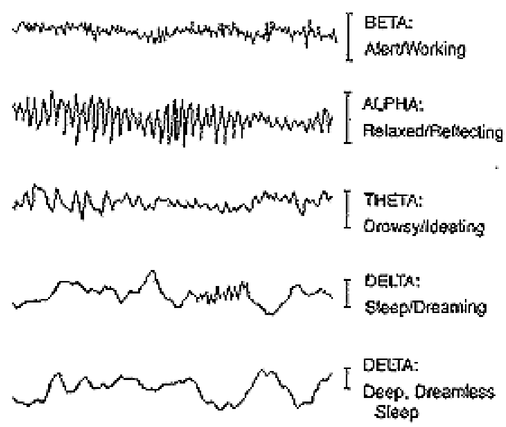
PET (positron emission tomography) is a nuclear medicine tool which uses X-rays. The subject is injected with a radioactive substance which contains positrons. The positrons then interact with electrons to produce electromagnetic radiation, and detectors sense that radiation and translate its path. In other words, if you're using a certain area of the brain to perform a function, that area of the brain will be illuminated on the scan. This allows inspection of chemical and electrical changes in the brain, rather than just physical changes. The drawbacks to the PET scan are the radiation exposure and the lengthy time it takes to produce each scan.

SPECT (single photon emission computed tomography) involves injection of a radioactive substance into the subject. As the substance decays, it produces gamma rays, which can then be measured and transformed into three-dimensional images of brain activity (Vancouver Hospital and Health Sciences).

Brain waves

We have been able to look at brain waves during meditation using EEG for quite some time to determine the type of brain wave produced by an area of the brain. For example, beta waves, the type we usually generate in our daily life when doing mental tasks, occur at approximately 14-30 Hz; alpha rhythms, the type we usually generate when quiet, relaxed, or, often, when in a meditative state, occur at approximately 8-13 Hz; theta rhythms, the type produced during some sleep states and some deep meditative states, occur at approximately 4-7 Hz; and delta rhythms, the rhythms of deep sleep, occur at less than 4 Hz. Waves higher than normal beta, often referred to as gamma waves, occur at levels of 30 Hz and above, and are related to a waking state sometimes referred to as "hyper-awareness."

EEG can measure the type of brain wave being generated by each area of the brain, and it can also show us whether there is coherence in these waves. "Coherence" indicates that different parts of the brain are in synchronicity with regard to brain waves. For example, if one part of the brain exhibits beta activity and another part of the brain shows alpha waves, there is no coherence. Coherence, or synchronicity, in the brain has been positively correlated with creativity (Orme-Johnson et al. 1977b). Studies have indicated that meditation improves coherence (Austin, 1999, p. 89).



(image courtesy http://www.crystalinks.com/medbrain.html)

Studies over the years have found various brain wave patterns during meditation. This could be due to the meditators being in different states of meditation while tested (i.e., initial stage versus deep meditation), being more or less advanced in their meditation practice (meditators with six months' experience might not show the same brain waves as 20-year meditators), in the scientists' not being aware enough of these things at the time of the test to screen the sample for them, or in not looking at specific areas of the brain which are most affected by meditation, since we have only recently learned what those are. In general, it is seen that the act of attention increases production of alpha waves. It therefore seems logical that the deliberate focusing that occurs in meditation would produce alpha. In most studies, early stages of meditation show increased amounts of alpha, while later in meditation, theta waves appear (Austin, 1999, p. 88). More specifically, Japanese researchers found fast theta and slow alpha in the frontal area increased during meditation (Takahashi, 2004). Some studies have found that during advanced meditation, after passing through enhanced alpha and/or theta, meditators later exhibit coherent beta and even gamma (very high-frequency) waves (Austin, 1999, p. 90). Richard Davidson's research also found a huge increase in gamma activity in the left middle frontal gyrus in meditators (Goleman, 2004, p. 12).

It also seems that the type of focus of the meditation can sometimes result in different types of brain waves. For example, studies which looked at concentration-type meditation found increased theta and alpha waves (Lutz, 2004). A study of Sahaja yoga meditators found that blissful experiences in meditation, characterized by absence of thought, correlated with an increased presence of theta waves (Aftanas, Sept. 2001). In addition, recent research has found that long-term Buddhist practitioners who focused on a state of compassion during meditation had more increased EEG gamma waves during, and long after, meditation, than did controls

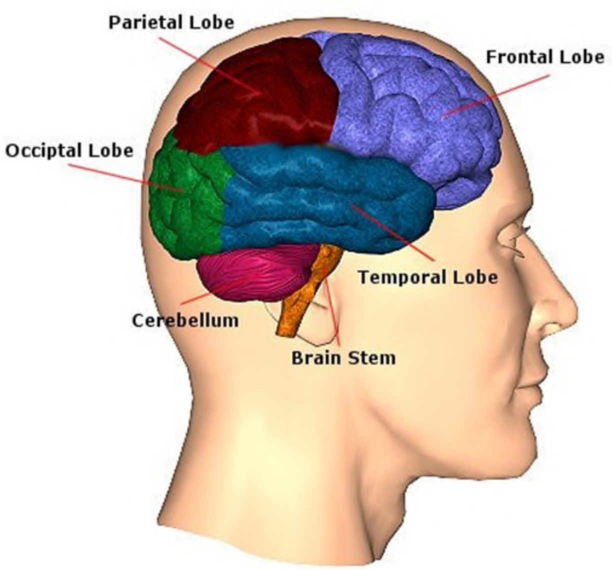
Other researchers have studied the neurological effects of different types of meditation. Lehmann et al. (2001) used EEG to study a long-term, practiced meditator while he was practicing four different types of meditation; for example, one form was mantra meditation, while another was focusing on the dissolution of self into emptiness. The practice of each form of meditation resulted in a different EEG pattern, suggesting that different types of meditation produce different neurological outcomes. This might be a reason that an individual would choose one form of meditation over another, or that one form would be more comfortable for them; it might be that their brain chemistry is more in need of the neurological effect of one type of meditation over another. For example, meditating on a mantra seems to produce different neurological effects than focusing on an image or concentrating on a light or visualizing the dissolution of self. Apparently, all types of focus, and all altered states of consciousness, are not alike; they produce different results in the brain.

While these studies show different changes in EEG, they all show a move away from beta, i.e., a change in brain waves from our normal waking state, and usually a shift toward alpha or theta rhythms, which are relaxing while concomitantly heightening awareness. However, much more than brain waves are affected by meditation. Now we will look at the response of various organs and chemicals in the brain to the practice of meditation.

Physiology

The frontal lobes

The frontal lobes are one of four pairs of lobes in the cerebral cortex, and are one of the most recently evolved portions of the brain. These lobes are associated with personality and emotion, and their development represents the evolution of humankind. In addition, they appear to be involved in cognitive and motor functions, such as "problem solving, spontaneity, memory, language, initiation, judgement, impulse control, and social and sexual behavior " (*Frontal lobes and personality*). They also contribute to our "capacity to feel empathy, sympathy, understand humor and when others are being ironic, sarcastic or even deceptive" (*Study poinpoints region in frontal lobes*). Obviously, they are extremely important to our functioning in the world, not only personally, but with regard to our impact on society.



(image courtesy http://www.neuroskills.com/index.shtml?main=/tbi/bfrontal.shtml)

Depression

With regard to frontal lobes, it appears that in general the right lobe (as well as the amygdala to some extent) is associated with negative emotions, such as depression and anxiety, and the left lobe is associated with positive emotions, such as happiness, enthusiasm, high energy and alertness (*Frontal lobe*) (*Finding happiness*) (Goleman, 2004).

People who have depression combined with intense anxiety have the highest level of right prefrontal lobe activity (Goleman, 2004). While it is not the purpose of this paper to discuss depression, it is becoming clear from recent studies utilizing the neuroimaging techniques now available to us, such as PET and fMRI, that there is a neurological component to depression, particularly in connection with the frontal lobes and the amygdala and their interaction (Irwin, 2004). It has been found that depression can be significantly decreased by electrically stimulating the left frontal lobe (Menkes, 1999). Goleman (2004) suggests that activity on the left side of the brain suppresses activity on the right side. As early as 1995, and in numerous studies since, it was indicated that the left prefrontal cortex and the left hippocampus showed increased activity during meditation (Newberg 1995). In an extremely important study in this field, Richard Davidson, who has done extensive research for many years in the areas of affect, neuroscience and meditation, led research on 25 subjects who were tested before and immediately after an eight-week mindfulness meditation program, then tested again at four months after the program. It was found that the meditators had significantly increased left frontal lobe activity compared with the non-meditators (Davidson, 2003). Since meditation affects both the frontal lobes and the amygdala, and since it seems to shift activity from the right to the left frontal lobe, it is logical that meditation could have an effect on depression.

The amygdala and fear

The amygdala, found in the temporal lobe, assesses our circumstances and determines if danger is present. When a frightening stimulus occurs, the sympathetic nervous system is activated by the hypothalamus, and cortisol is released from the adrenals.

Although there are many aspects of the neurophysiology of fear that are not yet clearly understood, we do know that the amygdala is involved in the experience of emotion in general, and particularly in fear (Bear, 2001). The amygdala is also believed to have an effect on aggression and memory. Information from the entire sensory system is processed through the amygdala, and what is one of the most primary human responses to sensory input? Emotion. If we see something frightening, we experience fear. If we hear beautiful music, we experience happiness.

Because of the nature of the association of memory, pain and fear in the amygdala, we can come to associate totally innocuous stimuli with pain and fear, and this can have devastating effects on functionality and emotional state. According to Richard Davidson, when exposed to a startling event, those who come back to baseline quickly are those who have less activity in the amygdala and more activity in the left prefrontal cortex. It appears that these responses are subject to change, though, and that our brain can be shaped by our experiences (Goleman, 2004, p. 179). When subjects in a study at the Center for Cognitive Neuroscience at the University of Pennsylvania were asked to maintain their emotional response to certain negative pictures, it was found through fMRI studies that the neural activity in the amygdala changed; the neural activity did not change when the subjects did not deliberately maintain the negative affect. Telling themselves to remain in a negative state, or focusing their attention on the negativity, resulted in changes in the amygdala (Schaefer, 2002).

The amygdala is more active when someone is depressed, anxious or has posttraumatic stress syndrome. The frontal cortex inhibits amygdala activity and so balances it; the balance between frontal cortex and amygdala activity is different for each person (Goleman, 2004), a unique neurological mix.

The normal amygdala has many receptors for opioid-like substances, and when opioids reach the amygdala, providing agonists for these receptors, the result is a reduction in fear reactions (Austin, 1999, p. 177). We have many receptors for both opioids and cannabinoids in our brain, but as yet do not know precisely what endogenous neurotransmitters they are supposed to receive (Bear, 2001, pp. 138, 148). Based on the results of meditation experiments studied so far, I believe that it is possible that practicing meditation stimulates production or release of our own internal opioid-like chemicals, which have the same effect as opioids in voiding the fear response of the amygdala. Eyes-closed contemplation would seem to me to be a natural thing for a human to do, and so it would also be natural for the brain to have receptors for the neurochemicals produced by this action.

Fear does have a positive role. Fear of lions with sharp teeth or large people with guns promotes our survival. Some protective fear, such as fear of lions with sharp teeth, is innate, while other protective fear is learned. If a child touches a hot flame, she learns to be afraid of fire. It is believed that the amygdala is connected with the emotional content of memories, so that an event that contained pain and fear would produce a more potent memory.

We would not have survived as a species if we had not learned to fear potentially damaging or life-threatening stimuli, events or beings. For example, it is good to learn to fear poisonous snakes and tornado funnels. On the other hand, because of the nature of the association of memory, pain and fear in the amygdala, we can come to associate totally innocuous stimuli with pain and fear, experiencing inappropriate and distressing reactions to everyday events, and this can have devastating effects on functionality and emotional state. If meditation does have the ability to correct imbalances in the amygdala and hippocampus, as some of the studies mentioned above seem to indicate, it could have a tremendous effect on society. What would our lives be like without unnecessary fear?

Hippocampus

The hippocampus relates to short-term memory, among many other functions, most of which are not clearly defined, and is thought to be related to Alzheimer's. It also appears that sustained high levels of cortisol kills hippocampus cells, as does posttraumatic stress syndrome and major depression (Goleman, 2004, p. 179), although it is not absolutely certain whether the emotional distress or the reduced hippocampal volume comes first. Since meditation seems to help the body maintain a lower level of cortisol (Infante, 2001), it would seem that it could help to protect our short-term memory, which could prove highly advantageous as we age.

Parietal lobes

The parietal cortex is associated with awareness of self, as well as with our perception of time and space (Newberg, 2004). Andrew Berger, in a study of monks, found that while meditating, the prefrontal cortex was extremely active, but that the parietal lobes were quite inactive (Newberg, 2001). Another study found that Tibetan Buddhist monks show an extremely active prefrontal cortex, and a suppressed parietal cortex, when meditating (Kaul, 2004). Seen in light of this research, meditative experiences that involve a dissolution of sense of self or feeling of timelessness seem quite logical. I am not suggesting that these experiences might not also be mystical in nature, but that the experiences are reflected in the physical body; we can now see the physical effect that the experiences have.

Breathing

Breathing is an act that meditators often deliberately watch or alter as part of their meditation practice. The act of conscious breathing alone can cause changes in brain chemistry. For example, deep abdominal breathing has a distinct physiological effect.

In a study on the effects of deep breathing, it was concluded that conscious, deep, abdominal breathing (VAB) promotes a high-frequency alpha state (8-12 hz) that results in a feeling of vigor and a state reduced anxiety. In addition, it appears that higher levels of available serotonin (measured by levels of 5-HT) resulted from this type of deep abdominal breathing; higher serotonin levels are associated with lower levels of depression. The changes occurred whether the breathing was done with eyes closed or open, after accounting for differences that naturally occur when the eyes close (Fumoto, 2004).

It has also been discovered that the exhale in the breathing cycle produces different physiological effects on the brain and other organs than does the inhale. Nerve cells fire during the inhalation and are quiet during exhalation. During meditation, breathing tends to slow, whether voluntarily or involuntarily (Austin, 1999, p. 94) and the exhalation gradually takes a greater percentage of breathing time, i.e., more time is spent on exhalation than inhalation. When we experience fear, more time is spent on inhalation than on exhalation, and the breathing (referring to the physical movement of the breath, not the actual location of the air) tends to be high in the chest. When we experience relaxation, more time is spent on the exhalation, and the breathing tends to be lower, in the abdomen. Conversely, by deliberately slowing our breathing and focusing on deep, abdominal breathing, we experience relaxation and its physiological effects. Experienced monks performing zazen spent 75% of their breathing time on the exhalation (Austin, 1999, p. 95). Apparently, breathing rhythms also affect the brain, particularly in the amygdala.

When breathing is quiet and there is prolonged expiration, nerve cells in the amygdala (where fear is experienced) fire less, which can, in turn, result in relaxation on a physical level (Austin, 1999, p. 98).

Heart and autonomic nervous system

Meditation is usually a quiet practice, and it would seem that the active functions of the physical body would not be affected. However, meditation apparently does cause changes in the autonomic nervous system, including the heart.

The autonomic nervous system (ANS), which includes nerves that control the heart, endocrine system, and the muscles of the digestive system, consists of two parts which serve opposing functions that help us maintain homeostasis. The first is the sympathetic nervous system, which is related to action, and the second in the parasympathetic nervous system, which is related to relaxation or passive functions. When one is activated, the other must come into action later in order to balance our nervous system.

The sympathetic nervous system prepares us for action in the case of emergency or threat. It works primarily for short-term emergencies. For example, in the face of perceived threat, adrenaline, a sympathetic neurotransmitter, prepares us for action and thinking that can ensure our survival. Our heart rate increases, and we are ready for action: the fight-flight response. The parasympathetic nervous system supports non-emergency functions, such as digestion, growth and the immune system; it works primarily for long-term maintenance purposes. The neurotransmitter acetylcholine is related to parasympathetic functions, as is noradrenaline. The two systems cannot function simultaneously, and they need each other in order to provide homeostasis. If the body is out of balance, and one of these systems predominates, damage can occur. When we lead a stressful life and do nothing to balance the stress, our sympathetic nervous system tends to be overworked, and the parasympathetic nervous system does not get an opportunity to do its work in restoring us to health.

Dr. Herbert Benson demonstrated that the effects of meditation are essentially the opposite of the fight-or-flight response. Meditation decreases heart rate, respiratory rate, blood pressure, oxygen consumption and muscle tension *(History of meditation as a clinical intervention*), thereby calming the sympathetic nervous system.

In a study comparing two types of meditators (novice Chi meditators and advanced Kundalini meditators) with a control group, it was found that meditators of both groups showed unusually high-amplitude heartbeats. It was concluded that meditation involves the sympathetic, as well as the parasympathetic, nervous system (Peng 1999). In a similar study in which three different types of meditation were studied, the cardiopulmonary function of 10 meditators was monitored and recorded during three types of meditation which used different breathing techniques: relaxation response (mantra, focus on the breath), breath of fire (rapid, intense breath through the nose), and segmented breathing (eight equal inhales, eight equal exhales). High-amplitude, low frequency heart rates were observed in the relaxation response and segmented breathing meditators. High-amplitude, low frequency heart rates had been observed in previous studies involving chi, Kundalini, Zazen and rosary mantra meditation. The breath of fire meditation breathing was different from these others types of meditation in that it resulted in an increase in heart rate (Peng 2004). Yet another study looked at the effect of meditation and other yogic practices in a three-month program, and found that cardiorespiratory performance improved significantly (Harinath, 2004). Meditation might seem to be a quiet pursuit, but it clearly does affect the autonomic nervous system, at least the heart rate.

Immunity

In Richard Davidson's mindfulness meditation study in which subjects were given a mindfulness meditation program, given a flu shot, then tested again at four months after the program, it was found that, in addition to significantly increased left frontal lobe activity, the meditators had developed significantly more flu antibodies related to the particular flu vaccine than did the non-meditators. There was a correlation between the amount of increased frontal lobe activation and the amount of vaccine-related flu antibodies. Meditation had a positive effect on both affect and immunity (Davidson, 2003).

Neurotransmitters

Melatonin

Melatonin is a hormone and antioxidant produced in the pineal gland that affects our sleep/wake cycle, among other things. When bedtime approaches, levels of melatonin rise and we fall asleep; toward morning, the levels fall and we awaken. It is believed that in addition to being an antioxidant, it fights physiological aging. Its production is closely connected with our exposure to light—too much light, particularly at night, and we don't produce enough melatonin to sleep; too little light exposure, and we have levels that are too high. When melatonin levels do not arise appropriately at night, we have difficulty falling asleep. When melatonin levels are too high during the day, some people become depressed; this is what probably causes seasonal affective disorder which occurs in the winter months in cold climates.

Experienced meditators practicing either TM® or another well-known form of meditation had higher plasma melatonin levels at night following meditation than they did on a control night when they did not practice meditation (Tooley, 2000). In another study, the nocturnal melatonin levels showed an increase after three months of meditation, and the higher the nocturnal melatonin levels, the higher the subjects scored on well-being (Harinath, 2004).

Serotonin

Neurons containing serotonin are associated with emotion. Serotonin receptors are found in the amygdala and other locations associated with aggression. Too little available serotonin can cause depression, and it is also possible that serotonin levels are related to obsessive-compulsive disorder. As mentioned above, in a study on the effects of deep breathing, in addition to other effects, it appears that higher levels of available serotonin (measured by levels of 5-HT) result from deep abdominal breathing, which might stave off depression (Fumoto, 2004). This is the type of breathing that usually appears naturally when meditating.

Dopamine

Dopamine levels are associated with aggression, schizophrenia and ADD/ADHD. Extroverted people often have higher spinal fluid levels of dopamine breakdown products, indicating an increase in uptake of dopamine. In one experiment, people who exhibited aggressive behavior (one type of extroverted behavior) practiced meditation for six months. At the end of the six months, the aggressive meditators' dopamine breakdown product levels had declined significantly, suggesting that meditation might reduce aggressive tendencies (Austin, 1999, p. 201).

One study using PET scan showed an increase in dopamine release, associated with lower aggression, during Yoga Nidra meditation, as well as an increase in EEG theta activity (Kjaer, 2002). Current research indicates a connection between ADD/ADHD and dopamine irregularities; I believe that it is possible that studies of the effect of meditation practice on these disorders and on dopamine breakdown and its agonists/receptors might prove useful in finding a non-harmful treatment for ADD.

Cortisol

Cortisol is a hormone that is released when the autonomic nervous system attempts to deal with a stressor. It pumps up our nervous system so that it can think and move faster and better. If the cortisol production continues over the long term, without allowing the body's parasympathetic nervous system to reestablish balance in the body by relaxing the neurological effects of the cortisone, aging and many stress-related disorders are in store.

In addition, elevated cortisol levels seem to have an effect on our affect and our personality, even when we are children. In a study involving young children, high cortisol levels were hypothesized to be positively associated with withdrawal-type behaviors, such as social wariness, and low cortisol levels were believed to be related to approach-type behaviors, both negative and positive, such as school engagement and socializing. It was determined that higher cortisol levels at age 4.5 predicted more internalizing behavior and social wariness in the children (Smider, 2002).

In a study of TM® meditators, those who had practiced meditation had a lower hormonal response to stress than those in the control group, and a beneficial effect on the sympathetic–adrenal medullary system was also observed (Infante, 2001), indicating that meditation does aid the body in balancing the cortisol levels pursuant to exposure to stress (Goleman, 2004, p. 179). Higher levels of cortisol produces more stress and also physiological damage over time, so being able to maintain a lower long-term level of cortisol is a very healthy thing.

Different strokes for different folks?

In a study which used Su-soku, a Zen meditation technique in which the breaths are counted, and the mind is stilled by continuously returning to the counting of the breaths, it was postulated based on test results that people who possess certain characteristics prior to meditation are more likely to exhibit certain physiological changes pursuant to meditation. In other words, one personality type might respond differently physiologically to a certain type of meditation than would a different personality type. If that is true, it might be that certain types of meditation are more beneficial for certain personality types (Takahashi, 2004).

Other researchers studied the neurological effects of different types of meditation on an advanced meditator, and found that the areas of brain activity change with the method of meditation being practiced (Lehmann, 2001). The practice of each form of meditation resulted in a different EEG pattern, suggesting that different types of meditation produce different neurological outcomes.

Perhaps the many different techniques for meditating arose in response to the needs of different types of personalities. It might be that a reason that an individual would choose one form of meditation over another, or that one form would be more comfortable for them, is that their brain chemistry benefits more from the neurological effect of one type of meditation over another. For example, meditating on a mantra seems to produce different neurological effects than focusing on an image or concentrating on a light or visualizing the dissolution of self. Apparently, all types of focus, and all altered states of consciousness, are not alike; they produce different results in the brain (Lehmann, 2001).

I believe that it is possible that advanced meditators would show more difference in areas of the brain affected by differing meditation practices than would beginners, who might show little differentiation in brain function between one method and another. In other words, it seems likely that becoming more advanced in meditation practice would also result in the brain being more specialized and proficient in its activity, particular in light of recent research which indicates that the brain can "learn" much more than we previously suspected with regard to adapting its neurophysiological functioning. This is just an hypothesis, but one which I hope will be studied further.

Conclusion

Richard Davidson has shown evidence in his research that suggests that the practice of meditation can inhibit negative emotions and foster positive ones. Each of us tends to have a balance of activity between the left and right frontal lobes that remains fairly constant (Goleman, 2004). Yet we possess the ability to utilize a tool that will allow us to alter that balance easily and thereby improve our lives: meditation.

Dr. Davidson has also gathered the first data of the effect on brain activity of the deliberate generation of the state of compassion, and is continuing with research to see if these effects hold constant for all meditators (Goleman, 2004). This work is breaking new ground in the field of neuroscience, as research has until now focused on correcting negative emotions, rather than studying the effect of positive emotions and states and how they might be better cultivated.

While some are reluctant to associate spiritual or religious states with specific brain activity, in the fear that this justifies a belief that spiritual experience is just a neurological event, I believe that it can also be viewed in the opposite manner. Possibly, guiding ourselves into a state into which our brain chemistry is conducive to spiritual experiences allows us to experience higher states of consciousness more easily.

Thanks to current imaging techniques, we can see now that we actually have the power to change our own brain chemistry: the power to create the lives we want really does lie within us. If practicing meditation results in our being able to adjust our own brain chemistry and other physiological functions, then our ability to regulate our own health, physical, emotional and cognitive, is within our reach. And it doesn't cost a cent.

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