



THE NEUROSCIENCE OF MEDITATION

AN INTRODUCTION TO THE SCIENTIFIC
STUDY OF HOW MEDITATION
IMPACTS THE BRAIN

BY ERIC THOMPSON

The Neuroscience of Meditation

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Impacts the Brain

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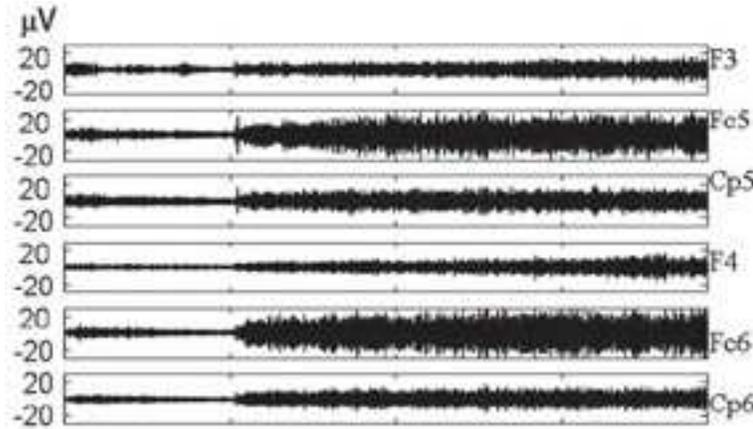
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CHAPTER 3

Brainwave States in Science

Electroencephalography



In the last chapter we highlighted brainwave patterns as rhythmic electrical signals emitted by the brain as neurons fire in on-and-off cycles. Science is able to record these signals using electroencephalography (EEG), discovered by Hans Berger in 1929. An EEG machine uses electrodes placed on the scalp to record the brain's electrical activity. And with the help of sophisticated computer analysis, the EEG can be used to translate these seemingly chaotic electrical signals into more readily understandable patterns. Rather than detecting the patterns of individual neurons, however, the EEG reads the electrical fields emitted by large groups of neurons.

The EEG records the waves of electromagnetic energy as they reach the surface of the scalp, making it very accurate in terms of measuring brainwave activity in real time. However, because the EEG is more sensitive to the electromagnetic signals that are closer to the surface of the skull, it tends to be less accurate when attempting to determine what is happening in specific areas of the brain, especially areas deep within the brain (i.e., subcortical).

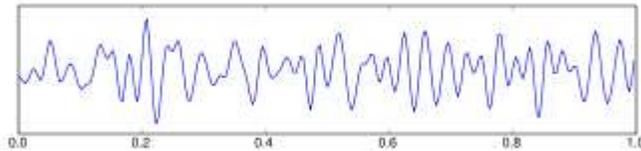
I realize that this may be more information than you care to know about brainwaves, but, as we further explore a scientific understanding of how brainwave patterns affect us, this information can help us see how the scientific community has come to its conclusions. It should also be understood that, although we will be exploring the states of consciousness associated with individual brainwave patterns, all of the patterns are actually present in our brain activity throughout the day. In other words, though some patterns may predominate in certain areas of the brain during specific activities, the truth is, the brain is producing a sophisticated blend of brainwave patterns all day long.

Brainwave Patterns – A Deeper Look

While the last chapter touched on the various states of consciousness and biological processes correlated with the five brainwave patterns recognized by science, this chapter will more deeply delve into the scientific study of brainwaves. As you read the descriptions and explorations of each pattern, try to recall specific instances when you were experiencing these patterns. Become as intimately acquainted as you possibly can with the interior experience of each pattern, as this

will help you to more profoundly realize not only how these states can radically shift your experience of life, but also how you can more consciously evoke and navigate these states to change your life in positive ways.

BETA: 13 – 40 Hz



The Beta brainwave pattern is a fairly wide-ranging pattern that spans from low Beta to mid Beta to high Beta. The lower end of the Beta spectrum (13 – 15 Hz or cycles per second) generally indicates a calm attention imbued with the beginning stages of involved interest. This pattern is also within the bounds of the Sensorimotor Rhythms, the training of which through neurofeedback has been found to significantly enhance the experience of flow states, wherein one feels exceptionally composed, self-assured and connected to the environment.

Mid Beta (16 – 22 Hz) is associated with externally focused attention. This is the pattern that helps us attend to daily activities with clear focus. This is also the predominant pattern that is activated when we our minds are busy judging, critiquing and chattering about the world within us and without us. Although this can be a very healthy pattern to cultivate, too much of it can lead to increased anxiety and eventually mental exhaustion. To live primarily in this pattern, as many people do, is to live unaware of the deeper potential that lies within. A perpetual mid to high beta pattern can eventually give way to increased stress and displeasure with life.

When brainwave patterns begin ranging between 23 to 40 Hz, there is often an increase in anxiety and muscle tension, sometimes even anger. This is high Beta, the pattern often associated with peak performance in athletics. If you've ever been in a situation wherein you were expected to perform at a high level but you felt unprepared, your brain may very well have been operating in a high Beta pattern. The same is true if you have ever cursed at oncoming traffic while driving!

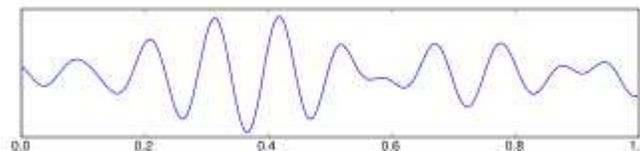
According to Dr. Les Fehmi, too much Beta activity indicates a narrow focus that over-stimulates the sympathetic nervous system, the branch of the autonomic nervous system involved in the fight-or-flight response. Spending extended periods of time in this pattern can be costly, because it consumes the energy provided through the nervous system at a very high and inefficient rate, arousing heart and respiratory rates beyond what is necessary for general daily activities. In addition, the accrued stress agitates the mind and emotions, giving rise to even more stress.

Staying in this mode of attention throughout the day for weeks on end is comparable to the state in which threatened animals preside as they remain in a constant state of alert attention in the presence of predators. This inefficient use of our attention weakens the central nervous system, reducing our capacity to respond to daily challenges from a state of deep resourcefulness. Furthermore, a prolonged sustaining of this state can indicate either the suppression (i.e., the conscious covering up) or repression (i.e., the unconscious covering up) of traumatic or disturbing emotional material.

Specific Scientific Studies Involving Beta Activity

- In 2005, Dr. Ruth Olmstead found a significant improvement in WISC-III arithmetic scores in children with ADHD when stimulated with brainwave entrainment in the high Beta and Gamma range.
- Madhavi Rangaswamy and colleagues conducted a study in 2005 in which alcoholics were found to have greater activity in all three bands of the Beta bandwidth (i.e., low, mid and high) than non-alcoholics. They interpreted this excessive Beta activity to be a possible sign of an imbalance between the brain's regulatory systems for excitation and inhibition. Still others have taken this interpretation further to suggest that alcoholism is the result of an attempt to self-medicate one's own neurological imbalances.
- In a study conducted by Richard Cauley Kennerly, brainwave entrainment stimulation in the mid Beta range significantly increased memory in three out of four dependent variables.

ALPHA: 8 – 12 Hz



Though Alpha becomes active at the onset of drowsiness just before bedtime, it is also often involved in meditation and deeper states of effortless attention. When the eyes are closed, the occipital lobe of the neocortex, which is located on the outer surface of the brain at the back of the skull, tends to emit Alpha band signals.

According to Dr. Les Fehmi, Alpha activity is often associated with spontaneous surrender to the moment. As a leader in the field of neurofeedback, Dr. Fehmi also discovered that, simply by imagining space, it is possible to produce phase synchronous Alpha and thereby counteract the habitual narrow focus of excessive Beta activity. He found a positive correlation between time spent in phase synchronous Alpha and increases in positive flow states, where anxiety evaporates and movement becomes fluid and effortless. Dr. James Hardt, another pioneer in neurofeedback, connects synchronous Alpha activity with creativity, forgiveness and Zen meditation.

Alpha has also been theorized to act as a bridge between the conscious and unconscious minds. For example, if we experience a forgotten memory from early childhood while in a deep Theta state of consciousness, and if we then immediately open our eyes and go straight back into an outwardly focused state of busy activity, that immediate jump from Theta to Beta will often keep us from consciously recalling the memory that emerged while in a deep Theta state. However, if we make a mental note of the memory and consciously intend to remember it, while also allowing ourselves to ease back into a waking Beta state (which means moving fluidly through Alpha), we will be better able to integrate the previously unconscious material into our conscious sense of self.

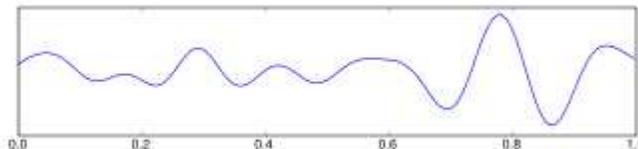
The Alpha frequency also appears to be the resonant frequency at which serotonin, the

neurotransmitter involved in mood regulation, is produced and released in humans. Drs. Patterson and Capel found that, when Alpha activity was evoked for at least 20 minutes through the use of brainwave entrainment, there was a significant increase in serotonin. It would seem that Alpha represents the first step in lightening our load, so to speak; when we are able to soften our gaze, let go, and take time to “smell the roses.”

Specific Scientific Studies Involving Alpha Activity

- Dr. Dan Landers of Arizona State University conducted a study in which it was discovered that, the more phase synchronous Alpha activity that was emitted precisely at the moment the arrow was released in archery practice, the higher was the accuracy of the shot. Other studies likewise have found a positive correlation between phase synchronous Alpha and sports performance.
- Ellen Saxby and Eugene Peniston conducted a study in which alcoholics, when treated with 20 sessions of Alpha-Theta biofeedback training, remained free of relapse when followed over a 21-month period.
- Creutzfeldt and colleagues found that, compared to non-meditators and beginning meditators, seasoned Zen practitioners were more able to sustain Alpha activity during basic mental visuomotor tasks.

THETA: 4 – 7.5 Hz



If you've ever been on the edge of sleep, at the point where you're just beginning to dream but you know you aren't quite asleep yet, you've experienced Theta activity. And when you dream at night, your brain is generating a lot of Theta signals, though dreaming can also involve spikes of Beta and Gamma activity. This also the neuro-electrical realm most associated with deep meditation, in which long forgotten images and memories can sometimes emerge spontaneously.

This connection with long-term memory is not an incidental one, as many studies have found correlations between Theta band activity and various functions connected to long-term memory. In fact, one brain area deeply implicated in long-term memory, the hippocampus, has been found to operate predominately in the Theta band of frequency. Still other studies have recorded positive correlations between memory retrieval and Theta frequencies.

This brainwave pattern has been found abundantly in the neocortex of young children, which in part may explain why the mental and emotional programming we receive as children has such a long-term impact on the formation of our personalities and worldview. Coupled with the fact that the human brain is much more plastic in childhood than in adulthood, this governing Theta frequency during childhood can result in both very positive and very negative outcomes, depending on the external and internal environments in which we are raised. The strong presence of this frequency in childhood, though, is responsible in part for ability to absorb and assimilate large amounts of information.

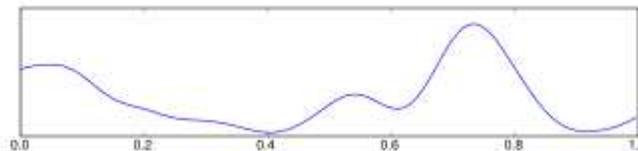
Theta has been theorized by many to be the energetic correlate of the human subconscious, the storehouse of our emotional trauma and repressed shadow material. Indeed, the research does

seem to support this notion, as there are numerous studies in the field of neurofeedback in which traumatic experiences are both uncovered and integrated in deep Theta states. Paradoxically, when such trauma is released, it is often the Theta state in which a profound sense of bliss—even ecstasy—is experienced.

Specific Scientific Studies Involving Theta Activity

- Aftanas and Golocheikine found a positive correlation between reported bliss states in Sahaja meditation and synchronized Theta train activity in the anterior frontal and midline areas of the brain.
- In a study conducted by Eugene Peniston and Paul Kulkosky, veterans suffering from post-traumatic stress disorder experienced a significant lessening of symptoms following intensive Alpha-Theta biofeedback treatment.
- E. Basar and associates designed and conducted a study in which “mental Theta” activity (i.e., the rhythmic trains of Theta activity that arise while focusing on problem-solving tasks) was located in the middle prefrontal and anterior cingulate areas of the brain. These areas have also been connected to the capacity for sustained attention.

DELTA: 0.5 – 3.5 Hz



Delta waves are the low frequency, high amplitude signals emitted during deep, dreamless sleep. The “high amplitude” designation is an important one because it explains in part why this stage of the sleep cycle plays such a crucial part in our capacity to recharge the nervous system and organs on a daily basis. We are all most likely aware that sleep deprivation can severely impede cognitive functioning, but, if prolonged indefinitely, it can even cause death.

Think about it. Have you ever woken in the morning after a heavy night of dreaming only to realize that you weren’t fully rested? A likely reason for this is because dreaming sleep carries a lot of Theta activity, while our capacity for awakening fully charged is largely dependent on the amount of Delta sleep we experience. These high amplitude (i.e., high-powered) emissions are essential for supplying the brain and body the energy it requires for full recovery and healing.

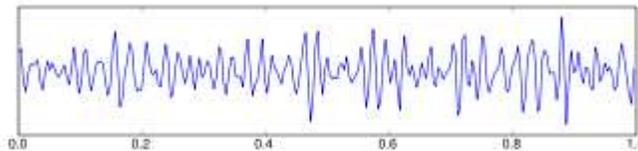
Not surprisingly, these signals have also been recorded when healers and qi gong masters channel healing energy. Technology-assisted meditation pioneer Anna Wise connects Delta activity with empathy and intuition. Her mentor, C. Maxwell Cade, saw the Delta realm as the neuro-electrical correlate of the human unconscious, including the collective unconscious. As we’ll discover in Chapter 5, in Buddhist and Hindu wisdom traditions, the Delta range (sometimes referred to as the *sleep self*) is associated with the subtlest aspect of our collective form, which we all share. In this light, it makes perfect sense that Delta activity would be involved in empathy and intuition, since the most highly developed forms of these intelligences appear to be sourced from a deeper than average awareness of some unified field within which we all arise and to which we all return.

Delta is also involved in extraordinarily profound states of meditation, when the self-identified witness dissolves, and there is no sense of self having any experience at all. This is where the subject-object duality collapses.

Specific Scientific Studies Involving Delta Activity

- Padmanabhan and associates found a significant decrease in pre-operative anxiety when subjects listened to a brainwave entrainment stimulus in the Delta range.
- In a study conducted by Mason and colleagues, advanced practitioners of Transcendental Meditation (TM) were found exhibit simultaneous Alpha-Theta and Delta activity during deep dreamless sleep. This activity was associated with a reported “witnessing consciousness” during a stage of sleep in which there is usually no sense of consciousness present at all.
- Gugino and team correlated increases of Delta patterns in the anterior areas of the neocortex with unconsciousness.

GAMMA: 40 – 100 Hz



Have you ever been in an emergency situation where time seemed to slow down, when your focus became almost super-human and you not only knew exactly what you needed to do, but were able carry out such actions with deep precision and ease? If so, you were most likely experiencing brainwave activity predominantly in the Gamma range.

Gamma activity is a very fast cyclic pattern believed to be involved in exceptionally high degrees of information processing. Scientific studies have correlated visual and auditory word processing with thalamo-cortical sweeps of Gamma-band activity. Gamma is also known to almost completely disappear after anesthesia is administered, which seems to indicate that it is intimately involved in waking consciousness. This is a significant finding, because science is still unable to fully explain how the brain is able join all of its sensory data into a unified whole. This is known as the *binding problem*. The collective data on Gamma activity suggests that this brainwave pattern may possess a kind of binding action capable of gathering all of the brain’s disparate sensory information together in holistic fashion.

Chapter 4 will further explore Gamma-band activity in Tibetan Buddhist *metta* (loving kindness) meditation.

Specific Scientific Studies Involving Delta Activity

- Haig and colleagues discovered that schizophrenics lack Gamma-band activity in information processing activities that normally feature Gamma activity.
- Hermann and Mecklinger demonstrated that Gamma activity is involved in high-speed memory comparisons.
- Stanley Krippner and his research team discovered a preponderance of Gamma-band activity in the occipital lobes (i.e., the back) of the brain 45 minutes after the ingestion of the hallucinogenic *ayahuasca* brew by members of the Santo Daime church in Brazil. This brew contains dimethyltryptamine (DMT) and beta-carbolines, such as harmaline and tetrahydroharmine.

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