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# Neuroplasticity and Mindfulness Meditation

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# Neuroplasticity and Mindfulness Meditation

By Richard Widdett

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## Introduction

Possessing approximately 100 billion neurons, the brain is an incredibly complex and powerful organ (Mastin, 2010). All areas of the brain serve a specific purpose and are interconnected, saturating the mind with thoughts and emotions. Meditation has introduced a way of assuaging the morass of thoughts occupying the mind. The link between mindfulness meditation and neuroplasticity has become evident over the last couple of decades, as new research has been unveiled supporting the claim that meditation can have a substantial role in the molding and shaping of the brain. Mindfulness meditation can be extremely beneficial to the body and to the mind by being the advocate of a fulfilled, happy, and stress-free life. Unnecessary limitations such as stress and overthinking can be mostly, if not completely, eliminated through daily meditation, making it an extremely valuable skill to attain. The potential for mindfulness meditation to be implemented in the field of aviation, especially with airline pilots and air traffic controllers, can even save lives.

## The Brain

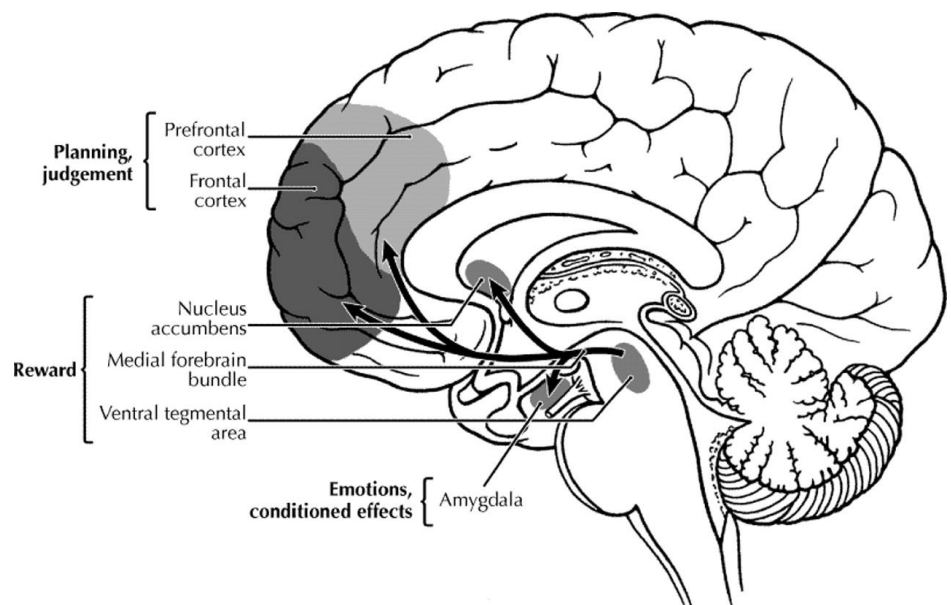
A basic overview of the brain structure and certain functions is necessary in order to fully comprehend the scientific aspect of the effect that mindfulness meditation has on the brain.

## Basic Structure

In his book “Mindsight” (2010), Daniel J. Siegel describes the “triune” brain as being comprised of three regions – the brainstem, the limbic area, and the cortex. These are the major regions of the brain and knowing about their functions can help one focus their attention in ways that will create the desired linkage among them. Linking the activity of these three regions is necessary in order to integrate the brain. This occurrence is known as “vertical integration” since these three areas are distributed bottom to top – from the inward and lower brainstem region, to the limbic area, to the outer and higher cortex. “Horizontal integration” is defined as the connections made between the left and right halves of the brain.

The brainstem controls the flow of messages between the brain and the rest of the body. It regulates basic functions and processes by receiving input from the body and sending that input back down again.

It has direct control over our states of arousal and shapes the energy levels of the brain areas above it; the limbic region and the cortical region. For



example, the brainstem determines if we are hungry, awake, or asleep. The brainstem is also responsible for our fight-or-flight response, or our brain’s

response to threats. This means that it controls the mobilization of energy distribution throughout the body and brain, choosing to either energize us for combat or for flight, or cause our bodies to freeze in helplessness. The limbic regions work closely with the brainstem and body to create our emotions and basic drives. They are what evaluate our current situation and motivate us to generate a response to the meaning we assign to our current situation. Another crucial function of the limbic area is that it allows us to form relationships and build emotional attachments to other people. The limbic area converts our moment-to-moment experiences into memories. Another part of the limbic area known as the amygdala is important in the fear response as it can subconsciously prompt the body into a survival response. The hippocampus also plays a role in memory as it links together widely separated areas of the brain, continually integrating neural firing patterns. The frontal cortex is what allows us to have ideas and concepts. This part of the brain actually makes neural firing patterns that represent its own representations, giving humans the innate ability to essentially think about thinking. There are good and bad aspects of the functions of the frontal cortex. It gives us the capacity to imagine and create. The drawback however, is that it is the reason many of us tend to overthink and linger around damaging thoughts. The master mapmaker of our physical experience is the posterior cortex, which keeps track of our location and movements. The prefrontal cortex, which is located just behind the forehead, is where we create representations of concepts such as time, moral judgments, and a sense of self. This area is extremely important in terms of interpersonal

communication since it enables us to pause before we act, have insight and empathy, and enact moral judgments (Siegel, 2010).

### Left and Right

The brain is divided into two halves, the left half and the right half. “Horizontal integration” is the term used to describe the integration of the left and right sides of the brain. During the first years of life, the right hemisphere is the more developed and more active. The right side of the brain represents our emotional and social selves. The left side is more conceptual, analytical, and fact-based. In essence, the right hemisphere is the creative side while the left hemisphere is more logical. The right side of the body is represented in the left hemisphere while the left side of the body is represented in the right hemisphere. Balance between the two hemispheres is essential for a healthy mind (Siegel, 2010).

### Neuroplasticity

According to Siegel (2010), “Neuroplasticity is the term used to describe the capacity for creating new neural connections and growing neurons in response to experience” (P.34). It occurs throughout the lifespan as we are in consistent exposure to experience. Neuroplasticity is the shaping of the brain due to internal and external input. Siegel (2010) comments on neuroplasticity:

One of the key practical lessons of modern neuroscience is that the power to direct our attention has within it the power to shape our brain’s firing patterns, as well as the power to shape the architecture of the brain itself (P. 59).

Through neuroplasticity, one is able to build and strengthen neural connections in the brain. Focusing our attention to stimulate the firing in certain neuronal groups helps establish new circuitry and reinforces their connections. Having an experience activates our neurons and can lead to the strengthening of synaptic connections. This can only occur under certain conditions such as emotional arousal, focused attention, and repetition. From the moment we are born, our brain is being molded and shaped based on our experiences. Relationships and our interaction with the world are what stimulate neural firing in our brains, sculpting our emerging synaptic connections.

## **Meditation**

Meditation can be used to develop a number of mental skills. Some examples are the ability to cultivate a longer attention span, develop emotional stability, understand the feelings of others and release one from the constraints placed on one's own happiness.

### **Definition**

Meditation is described as the practice of turning one's attention to a single point of reference. Focusing the attention on a single point rather than letting distractive thoughts occupy the mind is the essential goal of meditation. Kabat-Zinn states in the article "Mastering Your Own Mind" (2013), that meditation is about paying attention. Once attention is placed on the present moment, there are no



longer any harmful thoughts occupying the mind. There are several different types of meditation, however the focus of this thesis will be placed on the art of mindfulness meditation. This form of meditation specializes in the focus of attention and awareness of the present moment.

## Benefits

The world we live in is full of distractions. Being able to control our attention is a skill that can be refined through the consistent practice of meditation. Meditation is a way to stabilize the mind. The mind is inherently distractible by nature and meditation is a way of enhancing our attention span in order to reduce or even eliminate distraction. Meditation allows one to become lucid and calm in the everlasting turmoil of life. Daily exposure to overwhelming amounts of media can easily distract the mind from focusing on what is really important, living. Stressful situations can be mitigated through brief meditation and relaxation.

## Flow

In the article “Mastering Your Own Mind” (2013), another state of mind is described: “Meditators find that when they stop taking their own emotional upheavals so seriously, the self drops away. They process the world more directly. Absorption, a state similar to what is known as “flow,” increases.” Flow is the so-called secret to happiness and is a state of mind that allows one to place their full attention on the task at hand. It is a state of consciousness that makes one’s experience genuinely satisfying and gives one an “optimal experience.” This optimal experience is filled with enjoyment, creativity, and total involvement with life.

Flow can be achieved while performing any type of activity and is fueled by continuous positive feedback from the mind. Mihaly Csikszentmihalyi describes in his book "Flow" (2008), "when the information that keeps coming into awareness is congruent with goals, psychic energy flows effortlessly" (P.93). This also allows one to remain calm and focused in demanding situations.

## **Mindfulness**

### **Definition**

There are several definitions of mindfulness however they all relate back to the same basic principle and the main goal of mindfulness practitioners; being present. In his book "Mindsight" (2010), Daniel J. Siegel defines being mindful as "a way of intentionally paying attention to the present moment without being swept up by judgments" (P.106). Being aware of the present moment and realizing that it is the only time frame that is tangible and real can be extremely beneficial to the mind and body. Many overlook our capacity to access mindfulness and our ability to reduce stress to a minimal level, if not eliminate it altogether. Jon Kabat-Zinn defines mindfulness as "the ability to pay total attention to the present moment with a nonjudgmental awareness of the inner and/or outer experiences" (Wilson, 2013). Mindfulness means both cultivating nonjudgmental awareness of a specific object and seeing deeply into things.

## Origins

According to Bryant and Wildi (2008), mindfulness has been developed for over 2500 years within Buddhist traditions as a powerful tool for self-development. Mindfulness didn't enter mainstream Western psychotherapy until the 1940s with Gestalt therapy. It used to be a practice only used in the closest meditation circles, but is now becoming a greater mainstream interest. The term "mindfulness," translated from the Pali word *sati*, was coined by a British scholar named T.H. Rhys-Davids. The Buddha defined *sati* as "the ability to remember."

## Benefits

The benefits that come from mindfulness are seen through physical, cognitive, and emotional changes in one's life. Some of the physical benefits that come from mindfulness meditation are that it improves the immune system and also reduces cortisol and blood pressure. Cognitively, it has been shown to boost attention and decrease rumination. Mindfulness is also shown to reduce emotional reactivity and improve resilience. These are the preliminary benefits of mindfulness meditation but many more benefits have been noted.

Mindfulness has been shown to lead to significant changes in the brain. Research shows that it can lead to more cognitive flexibility, better emotional regulation, creativity and innovativeness, higher levels of well-being, and more empathy due to increased levels of alpha and theta wave activity. "Mindfulness involves the ability to accurately recognize where one is in one's emotional

landscape and allows one to enhance one's understanding, empathy, and capacity for accurate analysis and problem-solving" (Bryant & Wildi, 2008).

## **Present Moment**

The practice of mindfulness meditation is oriented towards the cultivation of energy and focus of awareness on the present moment. One way of becoming mindful is by focusing the attention on breathing. Once one becomes aware of and notes every inhale and exhale, one can patiently return one's attention to one's breathing each time it wanders. Mindfulness is the ability to keep the object and purpose of one's attention in mind. This technique is pragmatic and can be done anywhere. Another simple way of applying mindfulness to one's life is to go outside and pause for a moment. The idea is to fully open up the senses to one's surroundings, noting all the sensations one can see, feel, smell, hear, and even taste. Realizing the beauty of nature and not letting any distracting thoughts come to mind allows us to have a moment to realize that we are living in the present moment and should not let the past or the future interfere with our current goals.

## **Mindfulness and Neuroplasticity**

The mental training of mindfulness meditation is shown to be no different than other forms of skill acquisition that can induce neuroplasticity. Meditators may be strengthening the neural circuitry involved in the voluntary control of attention through repeated practice in focusing attention. The careful focus of attention through mindfulness meditation amplifies neuroplasticity by stimulating the release

of neurochemicals. These neurochemicals enhance the structural growth of synaptic linkages among the activated neurons. By practicing regular meditation, neural networks in the medial prefrontal cortex are strengthened and stabilized.

State and trait-like effects are associated with meditation. State effects refer to changes that occur while an individual is actively meditating and trait-like effects occur gradually over time, persisting throughout the day as a consequence of sustained meditation practice (Baer, 2010).

## Studies

A plethora of studies have surfaced with research supporting the claim that meditation can lead to neurological changes. A recent study at Massachusetts General Hospital mentioned in the article “Mastering Your Own Mind” (2013), showed evidence that forty minutes of daily meditation appears to thicken parts of the cerebral cortex involved in attention and sensory processing. A brief meditation session is shown to be more effective than a nap in improving performance on tests that require concentration.

The Dalai Lama recruited Tibetan Buddhist monks for a study done in the Waisman Laboratory for Brain Imaging and Behavior at the University of Wisconsin-Madison. The findings from this research on the brain and meditation suggest that long-term practitioners had actually altered the structure and function of their brains (Davidson, 2010). Although these findings are based on practitioners with tens of thousands of hours experience in meditation, it serves as solid proof that the structure of the brain changes through meditation practices.

As previously mentioned, the amygdala is a region of the brain that determines how much stress we experience and is central in modulating our fear responses. In a study conducted by the National Institutes of Health, mindfulness meditation has been shown to reduce the activity of the amygdala and even change the size of this area of the brain (Wilson, 2013). After eight weeks of mindfulness meditation training, overstressed businesspeople found that the size of the amygdala actually shrunk compared to those who were not practicing mindfulness. This evidence is paramount to the implementation of meditation in a business setting. Having less-stressed workers results in increased productivity and efficiency making this a valuable investment for any business owner.

Other research mentioned in the article “Mindfulness and the Brain” (2013), shows changes in the prefrontal cortex of mindfulness practitioners. The prefrontal cortex is a region of the brain that is in charge of activities such as decision-making, regulating emotions, and abstract planning. People who are experiencing high levels of stress, such as those with post-traumatic stress disorder, have an overactive amygdala and an underactive prefrontal cortex. Mindfulness meditation improves prefrontal cortex functioning and increases its activity. Another area of the brain showing increased activity from this practice is the anterior cingulate cortex, a part of the brain that is closely connected to the prefrontal cortex. Greater emotional stability and less reactivity are benefits reported from the increased activation of this region of the brain (Wilson, 2013).

## Mindfulness in Aviation

The advantages of being fully in the present moment can certainly be applied to everyday life, but its benefits can be more far reaching than that. Being aware of the present can also have enormous benefits in the aviation industry. Voted the fourth most stressful job of 2014 by Forbes Magazine (2014), an Airline Pilot is constantly under tremendous pressure. Meeting tight schedules, flight planning around enormous thunderstorms, and having the safety of hundreds of passengers to account for on a daily basis are just a few of the driving forces of stress that an airline pilot will encounter.

### Stress Levels in Pilots

Stress can be caused by several factors including sleep-deprivation, excessive workload and managerial pressure. Some of these elements, by themselves, can sometimes be overcome through mild stress-relieving techniques. The combination of several of them however, can be detrimental to a pilot's judgment and ability. There are many cases of airline pilots being unable to cope with the stress and having a panic attack. One such occurrence happened on March 27<sup>th</sup>, 2012, when JetBlue pilot Clayton Osbon had a "brief psychotic disorder because of lack of sleep" (Francis, 2012). Osbon was forced to the ground by passengers and crew after showing signs that he was in an unstable condition and unable to complete a safe flight. Osbon's lack of sleep served as a mental impairment to his judgment and prevented him from fulfilling his obligatory duties as an airline pilot.

## Current Solutions

There have been certain efforts to implement stress-reduction techniques in the field of aviation. A self-check every pilot learns early in his or her career is the IM SAFE (Illness, Medication, Stress, Alcohol, Fatigue, and Emotion) checklist used to judge whether one is in a safe condition to fly or not. Although stress is one of the factors to be assessed, it is often overlooked or even ignored by pilots. With sleep-deprivation being a major contributor to stress among airline pilots, the FAA implemented a rule on pilot fatigue in December 2011. According to the Federal Aviation Administration, the new rule implements several new regulations including varying flight and duty requirements based on what time the pilot's day begins, flight time limits of eight or nine hours, and a 10-hour minimum rest period (December, 2011). This will surely reduce the chances of sleep-deprivation but only solve one of the many stress-inducers among pilots.

## Implication for aviation industry

The potential benefits of the implementation of mindfulness meditation in the aviation industry could be staggering. In the study "Dealing with Psychological Stress" (2001), 115 pilots from various-sized air carriers were surveyed investigating potential stressors and methods of dealing with stress. Meditation only ranked as one of the least utilized methods for dealing with stress. As previously mentioned, mindfulness is "the ability to pay total attention to the present moment with a nonjudgmental awareness of the inner and/or outer experiences" (Wilson, 2013). Based on this definition, mindfulness meditation could dramatically reduce



stress caused by worry, expectation and emotions. A pilot who is fully focused on the present moment does not allow his or her mind to wander from its task and is fully engaged in the task at hand. Based on previously mentioned research, mindfulness meditation has the ability to reduce the size of the amygdala and increase the size of the prefrontal cortex in the brain. This results in decreased emotional reactivity and improved decision-making skills as well as increased emotional stability. Airline pilots, with the proper training and education, are able to reach a state of flow and use it to strengthen their skill sets and ability to focus. This can be an extremely valuable asset to any airline.

## **Conclusion**

The practice of mindfulness meditation has major potential for not only a more fulfilled life, but also for use in the airline industry. Through the change in the structure of the brain, we are able to dramatically reduce our levels of stress, amplify our ability to focus and increase our overall well-being. Substantial evidence found in a plethora of studies has shown clear changes to areas of the brain such as the amygdala and the prefrontal cortex. The relationship between mindfulness meditation and neuroplasticity is clearly present and has far reaching potential in all areas life, from simple personal gains to the increased safety of a commercial airliner. The spread of knowledge of the benefits of mindfulness meditation is crucial to the practice gaining respect in a professional setting. Once there is a full understanding of how mindfulness meditation can be used in a business or aviation setting, it will begin to emerge as a common practice among professionals.

## References

- Adams, S. (July, 2014). The Most Stressful Jobs of 2014. *Forbes Magazine*
- Baer, R. (2010). *Assessing Mindfulness and Acceptance Processing in Clients: Illuminating the Theory and Practice of Change*. Oakland, CA: New Harbinger Publications.
- Bryant, B. & Wildi, J. (September, 2008). Mindfulness. *Perspectives for Managers*, 162(1-4), Retrieved from <http://search.proquest.com.libproxy.library.wmich.edu/docview/235120265>
- Chong, D. R. (October, 2001). Dealing with Psychological Stress. *ALPA Magazine*, Retrieved from [http://www.alpa.org/portals/alpa/magazine/2001/Oct2001\\_DealingPsychologicalStress.htm](http://www.alpa.org/portals/alpa/magazine/2001/Oct2001_DealingPsychologicalStress.htm)
- Csikszentmihalyi, M. (1990). *Flow*. Toronto, Ontario: HarperCollins Publishers.
- Davidson, R. (2010). Buddha's Brain: Neuroplasticity and Meditation. *United States National Library of Medicine*. <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1361002/>
- Davidson, R. J. & Lutz, A. (January, 2008). Buddha's Brain: Neuroplasticity and Meditation. *In the Spotlight*. Retrieved from <http://brainimaging.waisman.wisc.edu/publications/2008/DavidsonBuddhaIEEE.pdf>
- Duquette, A. (December, 2011). Press Release – FAA Issues Final Rule on Pilot Fatigue. *Federal Aviation Administration*. Retrieved from [www.faa.gov](http://www.faa.gov)
- Farb, N., Segal, Z., Mayberg, H., Bean, J., McKeon, D., Fatima, Z., & Anderson, A. (2007). Attending to the present: mindfulness meditation reveals distinct neural modes of self-reference. *Oxford Journals*, Retrieved from <http://scan.oxfordjournals.org/content/2/4/313.full.pdf+html>
- Francis, E. (July, 2012). Sleep Deprivation Blames for JetBlue Pilot's March Meltdown. *Abcnews*. Retrieved from [www.abcnews.go.com](http://www.abcnews.go.com)
- Holzel, B. K., Camody, J., Evans, K. C., Hoge, E. A., Dusek, J. A., Morgan, L., Pitman, R. K., & Lazar, S. W. (March, 2010). Stress Reduction Correlates with Structural Changes in the Amygdala. *US National Library of Medicine National Institutes of Health*. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/19776221>

Mastering Your Own Mind. *Psychology Today*. Retrieved from psychologtoday.com  
<http://www.psychologytoday.com/articles/200608/mastering-your-own-mind>

Mastin, L. (2010). Neurons & Synapses. *The Human Memory*. Retrieved from  
[http://www.human-memory.net/brain\\_neurons.html](http://www.human-memory.net/brain_neurons.html)

Siegel, D. (2010). *Mindsight*. New York: Random House Publishing Group.

Psychiatric Illnesses and Neuroscience Part II. (December 27, 2013). Retrieved from  
[http://tamingthepolarbears.blogspot.com/2013\\_09\\_01\\_archive.html](http://tamingthepolarbears.blogspot.com/2013_09_01_archive.html)

Wilson, A. (May 16, 2013). Mindfulness Meditation and the Brain. *Huffington Post*.  
Retrieved from [http://www.huffingtonpost.com/kripalu/mindfulness-meditation\\_b\\_3238677.html](http://www.huffingtonpost.com/kripalu/mindfulness-meditation_b_3238677.html)