Your Brain on Happiness:
The Neuroscience of Joy

By Peter B. Williams

This essay focuses on recent discoveries about the brain states of happiness, as well as practical tips for using this knowledge to increase happiness. Let's start with the first topic. The practical tips start on page nine if you want to focus just on that.

Happy Brain, Mindful Brain

Research pioneered by neuroscientist Richard Davidson and others has found that there are regions of the prefrontal cortex (PC) associated with happy and unhappy states (Figure 1). The cortex is the outer layer of the brain and is enlarged in mammals, particularly in humans. The cortex contains many of the higher human functions such as coordinating complex perception, abstract and analytical thought, attention, etc. The cortex is mostly undeveloped at birth and is therefore shaped strongly by experience.

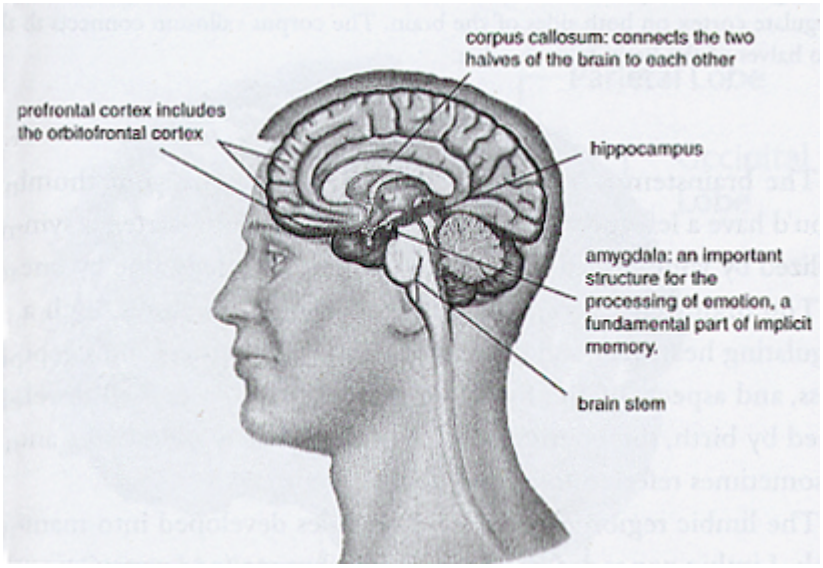

Figure 1. Key Regions of the Brain, from Siegel (2007, p. 33).

The areas of the brain that Davidson's research identified are in the middle prefrontal cortex, the left and right middle frontal gyruses (lMFG and rMFG). Study subjects with high levels of electrical activity in the lMFG reported feeling happy, enthusiastic, and alert (Dow, 2008). Tests showed these subjects were more able to notice and appreciate positive experiences and were more active in meeting life's

challenges. These subjects were generally found to be active participants in creating a happy life. In addition, these subject's self-reports showed them being better able to avoid difficult emotion (e.g., anxiety) than those with high rMFG activity, and better able to move through difficulty when it did arise. On the other hand, subjects with high activity in the rMFG reported high incidences of emotions such as worry, sadness, and irritation and more passivity in the face of life's challenges.

Davidson uses the ratio of left to right activity in the MFG as a kind of brain signature for happiness. He found that this ratio tends to be fairly stable for any person. While life circumstances can change fairly dramatically, events affect the MFG ratio only slightly, and it returns to baseline levels fairly quickly. Davidson's research appeared to show that people have a happiness set point, which seemed consistent with scientific findings that happiness is at least 50% genetically determined.

Davidson began to revise these conclusions when he began, in consultation with His Holiness the Dalai Lama, to test long-time meditators in his lab. Daniel Goleman (2003), in an article on the research, writes that senior practitioners in the Tibetan Buddhist tradition meditated inside an MRI machine so their brain states could be measured. Each subject had many years of meditation experience and had spent many months in silent retreat. These monks exhibited MFG ratios far outside of the range measured in the more than 200 people Davidson had previously studied. The meditators achieved these levels through deep meditative states focused on compassion. While these levels were not maintained outside of meditation, the findings suggested that the MFG ratio may be far more responsive to inner states than outer circumstances. This echoes the long-standing Buddhist view that mental happiness is most effectively sought through inner work. As common sense wisdom tells us, our attitude about what happens to us has more to do with our happiness than what actually happens to us.

As groundbreaking and impressive as these results are, they are not applicable to most laypeople, who have neither the time nor the motivation to meditate as much as Buddhist monks. Davidson's follow up studies on lay participants in a mindfulness-based stress reduction (MBSR) program addressed this concern (Dow, 2008). Researchers measured MFG ratios in subjects before and after they participated in this 8-week program, which required a daily meditation practice of 45 minutes. Results show that the MFG ratios of participants increased significantly after completing the MBSR program. Importantly, this improvement was measured when participants were not meditating. Participants also reported increased happiness, decreased anxiety, and tested for stronger immune systems. This study suggests that meditation, indeed, can cause a significant leftward shift in MFG ratios and that the happiness set point theory

needs to be revised. While we all know the benefits of meditation from our own experience, finding scientific validation for them will only boost the validity of meditation in the eyes of society.

A parallel and interesting finding is that mindfulness tends to be associated with activity in similar areas of the brain as the mood centers - the middle prefrontal regions. More research is needed to pinpoint exactly which middle prefrontal regions are activated with mindfulness. Initial research suggests the anterior cingular cortex (ACC) is centrally involved (Figure 2) (Siegel, 2008; Cahn & Polich, 2006). Other areas associated with attention include the dorsolateral and orbitofrontal regions of the PC (Figure 2).

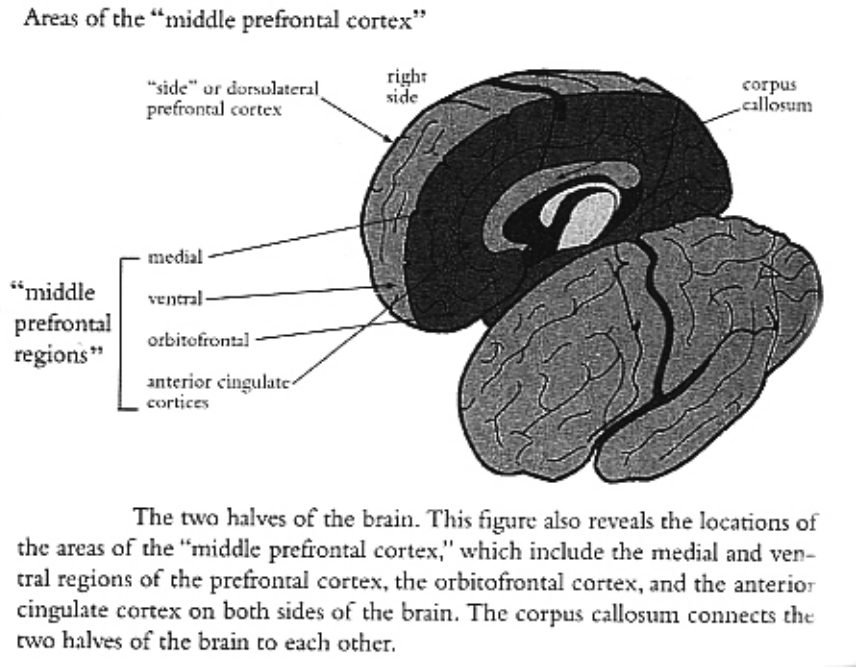

Figure 2. Areas of the Middle Prefrontal Cortex, from Siegel (2007, p. 34)

In a fascinating link between psychology and spirituality, neuroscientist Dan Siegel (2007), in *The Mindful Brain*, synthesizes a lifetime of research to conclude that mindfulness uses much of the same brain circuitry as our social engagement system. In empathizing with another we activate the MPC, especially the ACC region, among other areas. Siegel hypothesizes that mindfulness is a form of inner attunement, where we observe our own experiences much as we would observe another person. This attunement is particularly important in early childhood, when our social engagement system is wired into the brain by the experiences an infant has in relationship with

caregivers. The brains of adults who were securely attached as children exhibit many of the same functions as do brains of those who have practiced mindfulness: high integration of body, emotion, and thought; the ability to regulate and keep balanced the nervous system and emotions; empathy; self-knowing awareness; and the ability to pause before acting and assess the consequences, among others (Siegel, 2007). Siegel summarizes all this:

> We can propose that the interpersonal attunement of secure attachment between parent and child is paralleled by an intrapersonal form of attunement in mindful awareness. Both forms of attunement promote the capacity for intimate relationships, resilience and well-being.

Siegel's expertise in brain science should lend credence to the fact that he thinks mindfulness is the single most important skill for achieving happiness. It can give us as adults the same kind of nourishment that we may have felt in secure, loving relationships with our caregivers. As the saying goes, "It's never too late to have a happy childhood!"

I am fascinated by Siegel's theory because I have often thought of mindfulness as great inner parenting. Mindfulness meets experience exactly as it is. It listens without talking back, and keeps listening and keeps listening! It is non-judgmental and kind. It is not distracted. It is interested in everything. It stays calm when one is freaked out, unafraid when one is afraid, buoyant when one is depressed, and free of pain when one is in pain. Mindfulness knows our experience so intimately, yet always stays bigger than the experience, holding the space much like a parent does for a child.

When I used to teach ecology to kids for the Massachusetts Audubon Society, I would put to use Suzuki Roshi's advice to a student. He said that the best way for the student to discipline their child was to watch them. If they could really see what their child was up to in times of disruptive behavior, they would have a sense of how to respond effectively. This worked so well with the kids at the nature camps I used to run and it works so well internally. The watching of our unruly minds helps us contact our experience so intimately and we learn so much from just being willing to be with our hearts and minds as they unfold. Isn't it amazing that are beginning to know what this actually looks like in our brain!

Happiness and Neuroplasticity

That the brain can change throughout life is a second feature of the brain that is relevant to happiness. Early neuroscience seemed to endorse the adage that you can't

teach on old dog new tricks, holding the view that brain development is pretty much finished during childhood. This was, in part, based on the knowledge that the human brain doubles in size in the first six months of infancy, then again by age four, and then increases only another 10% by adulthood. Maybe Sigmund Freud was onto something - childhood just may be destiny.

In the last 15 years, many studies have shown that, in fact, the brain changes all through adult life, a phenomenon known as neuroplasticity. Learning a language or playing a musical instrument has been shown to increase in size the corresponding areas of the brain, whether one is eight or eighty years old. One study of neuroplasticity is worth mentioning, even though it involves monkeys and not humans, because the results are so dramatic. Dow (2008) summarizes a study in which owl monkeys were trained with food reward to place their finger on a spinning disk, a task that requires very precise coordination. In just a few weeks of frequently doing this feat, researchers found that the somatosensory cortex in individual monkeys, which maps what fingers do, increased by an average of 400%!

Furthermore, researchers found that the key feature that enlarged these brain areas was not so much the task as that attention was paid to the task. This was discovered when monkeys were trained to listen to tones that changed on headphones while performing the finger-placing task at same time. One group of monkeys was rewarded for indicating when tones changed, and one for when disc patterns changed. With the monkeys doing two tasks, this experiment tested which task they were paying attention to. Monkeys who recognized the tone changes had brain changes only in auditory areas, whereas monkeys who recognized the disk pattern changes had changes only in the somatosensory areas.

What one attends to, over and over, is what gets mapped into your brain. This is reflected in the neuroscience adage, "Neurons that fire together wire together." The brain is continually shaped by experience and attention appears to be a primary creator of brain circuitry. The monkey study corresponds with other studies on humans that show that mindfulness increases neuroplasticity in many parts of the brain (Siegel, 2007).

Neuroplasticity is a scientific finding that resonates with the importance the Buddhist tradition places on karma as the primary determinant of happiness. While karma in the context of rebirth and past lives is bafflingly mysterious, karma is very simple if we think of it as mental habit. Our past conditions affect our future happiness primarily in the form of the mental habits that we have developed. The more we focus on lovingkindness every day, the easier this state becomes in the future. Likewise, the

more frequently we become angry, the easier anger becomes. The mind greases its own skids, in the form of neuronal pathways in the brain.

Recent research suggests that a happy brain is more plastic and open to change than a depressed brain (Dow, 2008). Depression is associated with the shrinking of the dentate gyrus in the hippocampus, which is the part of brain that handles novelty (Figure 3). While the brain is always receiving new stimuli, in depressed people new stimuli may be so quickly co-opted by old mental patterns that it is not actually recognized as new. These old patterns happen to be deeply painful, focused on low self-esteem and hopelessness.

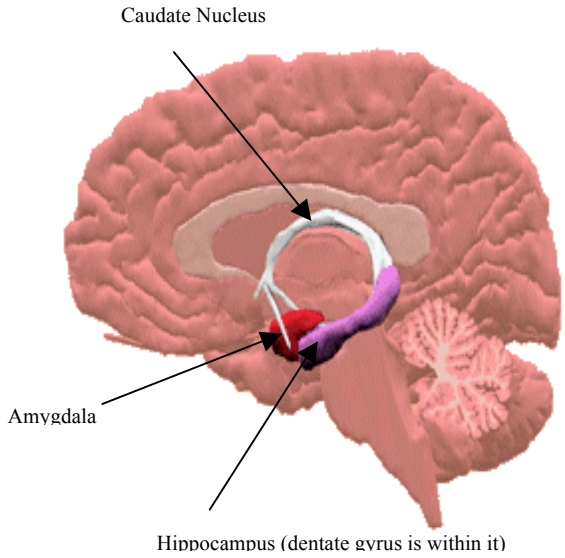

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Figure 3. The Amygdala and Hippocampus

A therapy that uses mindfulness has been scientifically shown to lessen depression. This approach, mindfulness-based cognitive therapy for depression, is rooted in the MBSR model, and focuses on group work, meditation, and the re-patterning of painful thoughts. This approach may work by activating the dentate gyrus, since mindfulness is based entirely on newness. Every experience greeted without conceptual overlay is fresh and alive. Suzuki Roshi, in the classic *Zen Mind, Beginner's Mind,* speaks to this novelty:

> "Our 'original mind' includes everything within itself. It is always rich and sufficient within itself. You should not lose your self-sufficient state of

> mind. This does not mean a closed mind, but actually an empty mind and a ready mind. It your mind is empty, it is always ready for anything; it is open to everything. In the beginner's mind, there are many possibilities; in the expert's mind there are few…When we have no thought of achievement, no thoughts of self, we are true beginners. Then we can really learn something."

This information about the dentate gyrus applies to all people, not just those who are depressed, because dealing with the freshness of present moment experience improves anyone's mood. Meditators can learn to be happy even in the midst of difficulty, as attending mindfully to some emotion like fear or irritation helps one feel alive and invigorated. In this sense, mindfulness is preventative medicine against depression.

Happiness and the Peripheral Nervous System

(Material in this section is taken primarily from the writings of Rick Hanson, fellow mindfulness leader and psychologist, and Rick Mendius, MD [Hanson & Mendius, 2009]. They have a great website on neuroscience and meditation at www.wisebrain.org.)

A third set of findings in neuroscience that is relevant to happiness relates to the parasympathetic nervous system (PNS). A major way to access happiness is to activate a branch of the PNS. Exercises in the last section describe how to do this. Here I will give background on the PNS.

The nervous system is complex, consisting of several major branches (Figure 3). The autonomic nervous system regulates basic body functions such as the heartbeat, breathing, glandular output, and sweating. The autonomic nervous system is divided into the parasympathetic and sympathetic nervous systems (PNS and SNS), which, respectively, are the brake and the gas pedal of the body. The PNS functions can be simplified as rest and digest, while the SNS functions are simplified as fight or flight. Both aspects are necessary to help us maintain a balanced and happy life.

When the PNS is activated, it releases acetylcholine, which leads to physiological changes that help one feel relaxed and contented. Studies have shown that an activated PNS decreases stress and blood pressure, and improves mood, digestion, the immune system, and sex drive. Get to know your PNS!

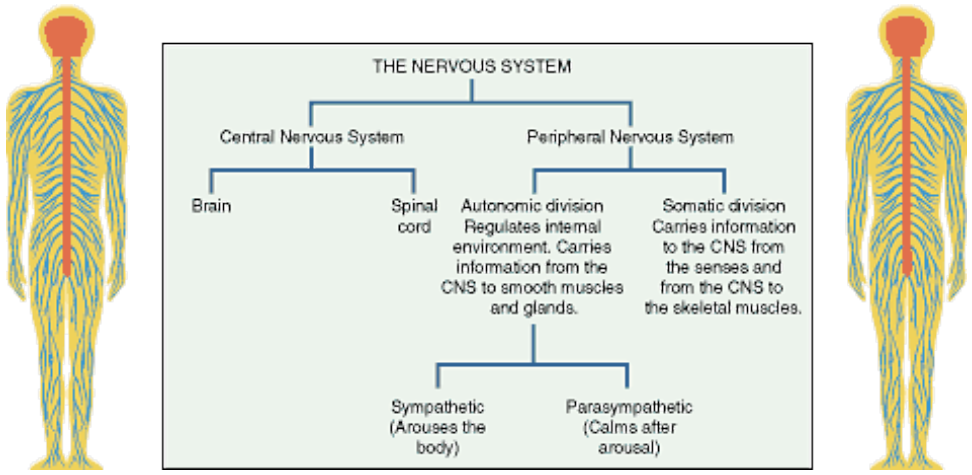

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Figure 4. The Nervous System

While the PNS helps the body relax and rest, the SNS is designed to help us take action. The SNS performs many functions less extreme than fight or flight. For instance, to stand up we need to increase our blood pressure, and it is the SNS that does this. The SNS activates and begins to raise the energy in the body about an hour before we wake up. The SNS is activated during play and excitement. The SNS is also activated anytime one is upset, be it sadness, fear, annoyance, or stress.

The fight or flight responses of the SNS occur when one feels in danger, whether physically or socially. In times of such arousal, the amygdala (Figure 2) is activated, which short circuits the thought centers in the frontal cortex, so that only very simple thoughts are possible, thoughts such as "danger" or "run" or "fight" or "what a jerk!" When a person responds to danger with fear, the SNS increases the flow of blood to the legs (for flight), and when danger is met with anger, the SNS increases the flow of blood to the arms (for fight).

Keeping our PNS and SNS in healthy balance is the key to happiness and mental health. Trauma upsets the natural rhythm between action and rest in the nervous system, resulting in a chronically activated SNS. Psychologist Peter Levine speculates that trauma occurs when energy activated by the SNS for fight or flight responses during a traumatic episode does not have the chance to get released. Such responses are thwarted by the perpetrator or by cataclysmic events such as car or plane crashes. This

energy is stored in the body and manifests in symptoms such as hypervigilance, flashbacks, heightened anxiety, panic attacks, physical illness, and so on. Levine's therapeutic approach, called Somatic Experiencing, works to bring the SNS and PNS back into balance. The entire process is done while the client is mindful of body sensations. The process activates the PNS through body awareness (explained in the exercises below), which provides a sense of well-being and safety and results in the willingness and resiliency for the client to relive the trauma event. This is done one small moment at a time, which excavates the stored SNS arousal, which is then released bit by bit. When the SNS arousal is discharged, the story of the trauma loses its hold and mental health and balance is restored.

EXERCISES BASED ON NEUROSCIENCE TO INCREASE JOY

1. Exercises for working with your happiness centers (MFG) in the prefrontal cortex.

● Meditation - Practices such as mindfulness and lovingkindness or compassion have been shown to increase the MFG ratio (Dow, 2008). So just keep on practicing!

● Mental noting of emotions - Research shows that the mental noting of emotions, as I have taught in previous classes, helps one be less reactive and more calm in the face of emotional difficulty (Wenner, 2008). It appears that the simple verbal bracketing of the complex mind-body events that are emotions decrease activity in the amygdala.

2. Working with the dentate gyrus in the hippocampus, the brain's center for dealing with novelty.

● Mindfulness - because mindfulness is always dealing with novelty, it is one of the best ways to combat depression preventively. It may increase the size of the dentate gyrus.

3. Activating the parasympathetic nervous system (PNS). Many of these are short exercises that you can do in the midst of a busy life. Most of these are borrowed from Hanson (2007).

● Deep, full breaths - While we let the breath be just as it is in mindfulness practice, if you are needing to kick start the PNS off the cushion, here is a good technique. On the inhale, fill the lungs fully in a relaxed way, pause for a second, and then exhale in a relaxed way. Do this for a minute. This works because deep inhalations expand the passageways (bronchioles) in your lungs, which the PNS

is in charge of constricting. So, you activate the PNS to bring the bronchioles back to their normal state.

● Body relaxation - Spend five minutes moving through the body and allowing all areas to relax. Start with the forehead and eyes, move to the tongue throat, and then to the diaphragm. These areas tend to hold chronic tension. Move to other areas in your own pattern.

● Mindfulness of body - The PNS regulates the body based on internal cues. When one is mindful of the body, the PNS is activated. Try noticing sensations throughout the body for just five minutes and see if you become calmer and more content. And, the more the better. Why not try 30 minutes every day?

● Yawning - yawning on purpose can activate the PNS. Try it a few times to see what happens.

● Fiddling the upper lip - fiddle the upper lip with a finger, making "blub, blub, blub" noises like a kid. Could work by stimulating salivation, which is controlled by the PNS, or because it is calming to have the fingers touch the lips, possibly because it reminds us of breastfeeding as children.

● Deepening positive emotion - Positive emotions dampen the SNS and activate the PNS, and lower cardiovascular reactivity, says Hanson. This exercise helps you deepen and savor the emotions of a positive experience. Emotions organize the mind as a whole, so positive experiences have global effects on the mind and body.

1. Help positive events become positive experiences:
   Remember a positive event, both the emotions associated with it and the sensory information - sights, smells, sounds, etc.
2. Extend the experience in time and space: linger with
   it, let it fill your body.
3. Sense that the positive experience is soaking into
   your brain and body - registering deeply in emotional memory. Keep relaxing the body and absorbing the positive experience, for up to 30 seconds.

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