You and Your Brain

Lesson 1: Brain Structure

Welcome to your Brain,

The human mind is an amazingly complex organ with an astounding number of responsibilities and mysteries. While scientists have begun to unravel the secrets of our minds, the research of the past century has raised as many questions as it's answered, and neurological research continues to grow. We cannot cover everything in this handout but our aim is to give an interesting 8 Lesson based outline, to understanding human awareness and the role of the brain in creating who and what we are as individuals.

The Nerve Cell

The most basic unit in our nervous system is the nerve cell (neuron). A nerve cell is made of three parts: the cell body, the dendrites, and the axon. The cell body is the heart of the nerve cell. The dendrites are branch-like extensions off of the cell body and act as the cell's receiving stations. Through the dendrites, a nerve cell can receive information from many other nerve cells. The axon is a projection off of the cell body and is the nerve cell's transmitter. Through the axon, the nerve cell sends information to other nerve cells or body tissues. In order for a nerve cell to signal another nerve cell or a body tissue, the cell must fire.

Firing

A nerve cell fires in response to a stimulus of some sort. This stimulus can be internal, such as a signal from another nerve cell, or external, such as light waves striking the retina.

What does it mean when a nerve cell fires?

When a nerve cell is at rest, it maintains what is called a resting potential, which is negative. This means that the cell carefully selects which salts, or ions, it will let in. When the cell gets the signal to fire, it opens special gates that let sodium ions into the cell near where the signal was received. Since sodium ions have a positive charge, the cell becomes positive in the area in which sodium ions entered. Then, the area of the cell adjacent to this new positive area throws open its sodium channels and becomes positive. This keeps happening until the electrical signal travels all the way down to the end of the axon. Once a section of the cell depolarizes (opens its sodium gates) it closes the gates again and re-establishes its resting potential.

So what happens when the signal reaches the end of one nerve cell? Does it jump to another nerve cell? It can. The place where the axon of one nerve cell meets the dendrite of another nerve cell is called a synapse. At a neuronal synapse there is a small space called the synaptic gap. Since there is a gap, it's not possible for the electrical signal to be continued from one nerve cell to another without the help of an intermediary. These intermediaries are called neurotransmitters. Neurotransmitters are secreted by the axons and recognized by the dendrites.

To understand how this process works, imagine that you and a friend are on either side of the Grand Canyon. Your job is to signal your friend to start running. She is too far away to hear you, so you light a fire hoping that she will smell the smoke and get the message. She does. In this example you are a nerve's axon, the smoke drifting across the canyon is the neurotransmitter, and your friend is another nerve's dendrite. Problems can arise if the axons produce too much or too little of a particular neurotransmitter or if the dendrites don't recognize a neurotransmitter properly. Many mental and emotional illnesses are caused by an imbalance in neurotransmitter levels

Brain Structure

The brain is really an odd-looking structure. It's strange to think that this wrinkled grey mass is what makes us who we are. The brain is about the same size as a coconut, is oblong in shape, looks like raw liver, and has a texture not unlike that of tapioca pudding. The wrinkled surface of the brain is called the cerebrum (cortex). The human brain has two halves called the left and right hemispheres. Although these two halves look roughly symmetrical, evidence suggests that they function somewhat differently.

The cerebrum is the part of the human brain associated with higher brain function. It's divided into four sections: Frontal lobe, Parietal lobe, Occipital lobe, Temporal lobe.

- The **frontal lobes** are associated with thinking, conceptualizing, and planning.
- The **parietal lobes** are associated with movement, orientation, calculation, and recognition.
- The **occipital lobes** are associated with visual processing.
- The **temporal lobes** are associated with sound and some aspects of memory.
- The **left temporal lobe** is usually responsible for speech.

The Cerebellum

The cerebellum is, evolutionarily, much older than the cerebrum. The cerebellum, like the cerebrum, has two hemispheres and a folded, wrinkled surface. Scientists believe that the cerebellum is involved in coordinating muscular activity; maintaining posture and equilibrium; and controlling the force, direction, and extent of voluntary movements.

The Limbic System

Buried beneath the two hemispheres of the cerebrum is the limbic system. The limbic system first emerged in mammals and evolutionarily is quite old. This part of the brain is in no way connected to awareness, but is incredibly important when it comes to our emotions, appetites, and urges. The limbic system is often referred to as our "emotion centre" and the main modules of the limbic system are the thalamus, hypothalamus, putamen, amygdala, and hippocampus.

- The **thalamus** acts as a switchboard operator, sorting and sending information to the appropriate parts of the brain.

- The **hypothalamus**, in conjunction with the pituitary gland, plays a vital role in several areas (including, but not limited to): maintaining proper body temperature, regulating energy levels, food intake, and growth.

- The **putamen** plays an important role in "memorized" movements. That is, movements that are so well learned, like riding a bicycle, that they almost seem automatic.

- The **amygdala** is responsible for fear.

- The **hippocampus** plays an important role in long-term memory.

The Brain Stem

Beneath the limbic system lies the oldest and simplest part of our brain, the brain stem. Reptiles' entire brains resemble our brain stem. The brain stem carries information from the body to the brain and regulates alertness, breathing, heartbeat, and blood pressure. The brain stem is comprised of the midbrain, pons, and medulla.

Phrenology

During the 19th century the "science" of phrenology was at its height. Phrenologists believed that the brain was the organ of the mind and was divided into distinct "organs," each responsible for certain personality traits or intellectual ability. Phrenologists were correct in thinking that the brain was the organ of the mind, but they oversimplified the problem of brain mapping and used horribly poor methods for assigning functions to areas of the brain.

Franz Gall, the founder of phrenology, determined the phrenological "sex centre" of the mind from observing that two young widows had warm skull bases. He assigned the "Organ of Combativeness" by observing that certain peaceful groups had heads that were small in that area. Phrenologists were quick to latch on to anecdotal evidence supporting their claims and were adept at explaining away contrary information. For example, suppose a very violent person had a small Organ of Combativeness. Phrenologists would have claimed that some other organ was causing the person's violent behaviour.

Phrenologists determined the size of a person's dubiously assigned organs by examining the size of bumps, bulges, and irregularities on the person's head. Most phrenologists would run their bare fingertips (Gall recommended using the palms of the hands) over a person's head to distinguish any elevations or indentations. Less frequently, callipers and other instruments were used. Employers often demanded that prospective employees produce a character reference from a local phrenologist. Social reformers were often urged to use phrenology to improve education and the criminal justice system. Today people might laugh at phrenology and its practitioners, but this sort of faulty logic seems to follow humankind like an errant puppy dog. Many people today have oversimplified the differences between the left and right hemispheres of the brain and have distorted the results of modern brain research into a type of modern phrenology.

Lesson 2: The Mind's Eye

You receive a great deal of information about yourself and your environment visually. As such, the visual system is an important part of our perception and self-awareness. But how does the eye collect and process the information it sees to you?

In many ways, the modern camera's design is based on the human eye. Like a camera, the human eye has an adjustable lens for focusing, is able to adapt to low light conditions, and has a surface (the retina) on which the light waves land and are registered. The human eye is composed mostly of water and in some ways resembles a water balloon. The interior of the eye is filled with watery fluid called the vitreous humour; between the cornea and lens is a fluid called the aqueous humour. All of this fluid is encased by the outer part of the eye called the sclera. The sclera is the "white" of your eye.

At the front of your eye, surrounded by the visible part of your sclera, is your cornea. The cornea acts as the course element of your eye's focusing system. Most of the light rays hitting your eye are bent by the cornea and then focused further by your lens. In other words, the cornea bends the light and sends in it the right direction. The lens then focuses that light so that a clear image hits the back of your retina. If your lens doesn't do this properly, you get a fuzzy image. (In other words, you need glasses.)

Behind the cornea are your iris and pupil. The iris is the coloured part of your eye and serves to adjust the diameter of your pupil. You can think of the iris and pupil as your eye's shutter system. The iris widens and narrows the pupil to adjust for the amount of light present. Your lens is located behind the iris. Surrounding the lens is the ciliary muscle, which changes the shape of the lens by contracting or relaxing, allowing you to change your focus. Your lens focuses the light wave passing through it and sends a sharp image to your retina. Your retina lines the back of your eye and contains neurons, called cones and rods , which possess light-sensitive pigments.

Seeing

When light hits these neurons, the light's energy changes the geometry of the pigments and causes these neurons to fire. The signals from these nerves are then sorted out by the lateral inhibition network. This network actually throws out some of the visual information your eye has registered to avoid flooding your brain with unnecessary visual data. Your brain doesn't need to "know" every thing to construct a reasonably accurate and functional image. The edited signal is then registered by the optic nerve, which sends that visual data to your brain, where it's processed further.

Why doesn't the brain need to "know" all the information?

The brain is basically interested in edges, or areas where light intensity changes quickly. If the brain knows that there is a particular change of light intensity at one place, and no change in light intensity until another place, it will "fill in" the intensity between the two. One of the advantages of the brain's focus on "edges" is that our world doesn't dramatically change appearance under different light conditions. In other words, the words on the page of a book still look basically the same whether you light it from one side or the other.

Does the lateral inhibition network have any side effects?

It does, and that's why optical illusions work. Most people know someone who is "colour blind." Complete colour blindness (when a person can see only shades of grey) is extraordinarily rare. Red-green colour blindness (when a person has difficulty distinguishing certain colours, especially red and green) is much more common. In order to understand colour blindness, it's important to understand a few things about the cones and rods in our retina.

Cones

Our retinas possess an area called the fovea. This is the part of the retina responsible for producing our sharpest images. When you focus on a particular object, the visual information about that object is projected onto the fovea. The fovea and its surrounding area contain the vast majority of cone cells. Cone cells are responsible for colour vision and function best under daylight conditions. Cone cells contain one of three photo-pigments. These pigments register blue, green, and red. Your mind processes, or blends, the information from different cone cells to produce the wide variety of hues you see. If someone lacks one of the three pigment types, they experience partial colour blindness.

Rods

The rod cells, which are fewer in number than cone cells, are responsible for night vision and for seeing in black and white. This is why, at night or under low-light conditions, you really can't distinguish between one colour and another. The few individuals who are completely colour-blind lack functioning cone cells and rely entirely on their rod cells to see.

Are more men colour-blind than women? Yes. That's because the genes that code for colour vision are located on the X chromosome. Men only have one X chromosome; women have two. For a woman to express colour blindness, both X chromosomes would have to carry the colour-blind mutation. A woman with one normal X chromosome and one "colour-blind" X chromosome has normal colour vision. Her sons, however, have a 50/50 chance of inheriting the "colour-blind" X chromosome. Colour-blind children are often misdiagnosed as having a learning disability because they do poorly following directions that involve colour.

Optical Illusions

Everyone is familiar to some degree with optical illusions. Optical illusions are fun because your mind is "tricked" into either seeing something that isn't there or creating a difference that doesn't exist. There are two types of optical illusions: Cognitive and Mechanical

Cognitive illusions work due to "pre-programming" in your brain that insists your brain interpret visual information in a certain way. Mechanical illusions are caused by eyestrain or over-exciting your retinal neurons -- as happens when you foolishly stare at the sun.

Your brain is pre-programmed to focus on the edges of an object. Our sense of perspective is entirely dependent on the way our brain is programmed. We are programmed to assume that objects that appear smaller are farther away. Artists have taken advantage of this fact for centuries to give their two-dimensional works a three-dimensional feel. In addition to "knowing" that "smaller" objects are farther away, our brain assumes that objects still occupy the same amount of actual space. For example, when we look at a football travelling away from us, it appears that the football is getting smaller. Due to the way our brains are pre-programmed, we intuitively know that the football is the same size. In other words, the size of the football is preserved in our minds.

Mechanical illusions are not due to the way are brains are programmed, but due to a mechanical occurrence in the eye. For example, if you stare at a flashlight you will see an after image. This happens because the neurons in your eye were so excited that they continued to fire after you stopped looking at the light.

Most people are aware that the perception of colour is relative. It's true! Take, for example, the appearance of your teeth when you put on lipstick. If you put on red-orange lip colour, your teeth will probably appear bright and whiter. However, if you put on red-purple lip colour, you'll see that your teeth look -- gasp -- rather yellow! Why does this happen? Your teeth certainly aren't changing colour. This phenomenon occurs because your brain is designed to look for contrasts in colour, just as it is in light intensity. So as you see, the perception of colour is not an absolute. Furthermore, prolonged exposure to colours can cause fatigue in cone cells. This will result in a change in the way that you perceive the colour of the object that you are viewing.

For example, if you put on a pair of orange-tinted ski goggles, the world will look orange for a while. Then you'll notice that things start looking "normal" again. But when you take off those goggles, you'll find that the world suddenly looks blue! Your brain has adjusted to account for the orange lens over your eyes. This adjustment is as the lens of your eye yellows with age. If your mind couldn't adjust for colour, the world would gradually turn yellow as you got older.

Lesson 3: Emotion

Humans communicate and make value judgments based on their feelings. How these emotions originate and how brain chemistry affects what we feel is what this lesson is all about.

The Emotion Centre

The limbic system is often referred to as the emotion centre of the brain. The limbic system itself is part of the non-conscious portion of the brain. In other words, without the higher brain functions of the cerebrum, you wouldn't be aware of the emotions generated in the limbic system. You would continue to generate emotions, but you wouldn't experience them consciously in the manner that you do now. Your emotions would continue to function without your awareness, just as the signals regulating your pulse and blood pressure function without any conscious effort from you. Interestingly, homeostasis (blood pressure, pulse, body temperature) is also regulated by the limbic system. The primary components of the limbic system are:

The Thalamus

The thalamus acts as the limbic system's receptionist. The thalamus organizes incoming and outgoing information and sends it to the proper destination.

The Hypothalamus

The hypothalamus, like the thalamus, acts in some ways as a relay messenger. The hypothalamus is responsible for sending emotional information to your body. That jittery rush you feel after a close call is due to a release of adrenaline in your body. The signal to release that adrenaline comes from the hypothalamus. The hypothalamus also plays an integral role in sex drive, particularly male sex drive. The area of the hypothalamus that is responsible for sex urges is located very close to the amygdala. Scientists speculate that such proximity could explain why aggressive urges and sexual urges are sometimes confused in males.

The Putamen

The putamen is responsible for familiar motor skills. This is the part of the mind that comes into play when you "learn" repeated actions to the extent that you no longer need to think about moving in a conscious fashion. Scientists believe that Tourette's syndrome is the result of an overzealous putamen. The putamen in a Tourette's patient causes the patient to perform "programmed" skills in unsuitable situations.

The Amygdala

The amygdala is a critical part of the limbic system. It's the brain's warning center -- responsible for fear. The fight-or-flight response you experience when you are threatened originates with the amygdala. It is thought to play a role in the development of phobias because it appears to be involved in a specific type of nonconscious memory -- conditioning related to negative stimuli. Since the amygdala is located in a nonconscious part of the brain, phobic people are unable to recall why they are frightened. They are only aware of their fear or unease.

The Hippocampus

The hippocampus is vital for recent and short-term memory. Individuals who have sustained damage to their hippocampus are able to recall older memories but are unable to recall the recent or immediate past. They are unable to create new memories.

The Three Levels of Emotion

The **primary emotions** are those most commonly associated with human feeling. They include happiness, sadness, fear, anger, surprise, and disgust. Normally, you recognize and express these emotions with relative ease.

The **Secondary Emotions** are often thought of as social emotions. They include embarrassment, jealousy, shame, guilt, and pride and are closely connected to the primary emotions. Some scientists believe that the secondary emotions are "blends" of the primary emotions, synthesized and processed by the cortex into more complex, new emotions. Scientists from this school of thought feel that the primary emotions are limited to love, fear, anger, and disgust.

The background emotions are the mood emotions. Contentment, calm, malaise, and tension are all background emotions. It's important to understand that the factors controlling background emotions are largely internal.

Be aware that emotions cannot, without mind-altering chemicals, be controlled. We aren't conscious of many of the emotions we experience and, frequently, we cannot clearly identify the inducer, or cause, of many emotions that we are aware of. Inducers can vary widely. What we feel is affected by our thoughts and memories as well as our health, diet, level of activity, and hormonal cycles. Even the weather can play a role in how you feel. While we cannot control what we feel, we can control how we express our emotions -- but even that control has its limitations. Most people will jump when startled, blush involuntarily when embarrassed, and experience pupil dilatation when excited.

Brain Chemistry

Science has made leaps and bounds in recent years in understanding brain chemistry and how brain chemistry affects human emotions. Scientists have identified more than 50 different types of neurotransmitters. The following six seem to be of particular importance.

Acetylcholine
It appears that acetylcholine plays an important role in attention, learning, and memory. Drugs that boost acetylcholine have provided some relief for Alzheimer's patients.

Dopamine
This neurotransmitter plays a role in both physical motivation and mental stasis. Low levels of dopamine are connected with Parkinson's disease; high levels of dopamine are connected with schizophrenia and hallucinations. Dopamine is also thought to play a role in some types of depression.

Enkephalins and Endorphins
Everyone has heard about a "runner's high" -- the sense of euphoria that follows sustained, strenuous activity. Scientists believe that this high is caused by the endorphins released during such activity. These neurotransmitters are similar in chemical structure to opiates. Like opiates, these neurotransmitters modulate pain, reduce stress, and induce a peaceful calm.

Glutamate
Glutamate plays an important role in forming neural connections. It's vital for learning and the formation of long-term memories.

Noradrenaline
This neurotransmitter acts like a stimulant. It heightens mood and creates a mental and physical sense of excitement.

Serotonin
Serotonin plays an important role in mood modulation. Low levels of serotonin are linked to depression. This is why Prozac, a drug that inhibits the re-absorption and degradation of serotonin, is often an effective treatment for depression. Serotonin is also associated with sleep, pain, appetite, and blood pressure.

Emotion is an integral part of the human experience. Humans communicate and make value judgments based on their feelings. Historically, science decried emotion as the antithesis of reason; a vestige of our primeval, more animalistic past. Science regarded emotion as the realm of artists and romanticists -- people who believed that emotion is a quintessential part of human life. Recent developments in neuroscience indicate that artists and romanticists were on to something about the importance of emotion as related to human wellness. Like the character Mr. Spock on the 1960s TV series, Star Trek, some people continue to consider emotion the weak link in human consciousness. It's important that this myth is dispelled. More and more evidence has surfaced indicating that emotion is not reason's adversary, but instead its partner. As this evidence mounts, more of us realize that emotions have evolved to our benefit and aid in human survival.

Everyone Has Feelings

Although some components of emotion are culturally influenced, the vast majority of emotions and emotional expressions cross national and ethnic lines. Thus, unless individuals suffer from brain damage or a chemical imbalance, during the course of their lifetime they will experience a range of emotions very similar to yours, regardless of their religion, nationality, or skin colour. While the notion that all healthy human beings experience joy, sadness, love, disgust, pain, and fear seems elementary to modern readers, this concept escaped many well-educated individuals in the 19th century. At that time there formed a schism in the public perception of emotion: emotion was simultaneously reviled as irrational and revered as uniquely human. We now see beyond this erroneous rift in public opinion and appreciate that emotion plays a vital role in our ability to reason, communicate, and avoid dangerous situations. This explains why emotion is such an impressively uniform part of the human experience. When the ability to properly register emotion breaks down, a person's ability to function well is seriously compromised.

I Don't Know What to Do!

Take, for example, the situation experienced by a patient named Elliot. As a result of an operation to remove a brain tumour, Elliot lost the ability to sense his emotions. Although Elliot's overall I.Q. remained the same after the operation, his ability to make decisions or complete projects was destroyed. Elliot experienced difficulty getting out of bed in the morning, prioritizing tasks, and recognizing emotional warning signs. Ultimately, Elliot lost his job and went bankrupt due to a series of questionable business ventures with rather shady characters. Elliot's problem stemmed from the fact that he had no emotional sense underpinning his choices and was unable to tell if one option seemed better than another option. Therefore, he had difficulty choosing an option and was unable to attach a sense of importance to a task.

So we see why emotions play such an important role in our ability to make decisions. They allow us to recognize pleasant from unpleasant, important from trivial, and, most significantly, they allow us to recognize threats to our well-being by providing us with a sense of "good" and "bad."

Lesson 4: Brain Chemistry

Recently, the differences between the two hemispheres of the human brain have captured the public's attention. Books covering the differences between "right brain" personality types and "left brain" personality types are exceedingly in vogue. Even advertisers have jumped on this bandwagon. However, much of this hullabaloo is unwarranted.

Most individuals have a perfectly functional corpus callosum, and the two sides of their brain are in constant communication with each other. While there might be certain preferences and issues relating to which side of the brain we use for what, such things rarely affect healthy individuals in truly noticeable or relevant ways. Some of the books that attempt to explain character in terms of "right" and "left" brain oversimplify the issues relating to personality. Nonetheless, that isn't to say that there aren't differences between the hemispheres of the mind. By studying individuals suffering from damage to one hemisphere, scientists have learned that the halves of our brain have some interesting differences, including how they experience emotion.

Mr. Positive (Left)

If one side of your mind saw the glass as half-empty and the other side saw the glass as half-full, the optimist would be your left brain. In fact, the left brain might be such an extreme optimist that it denied the glass lacked any fluid at all. Stroke victims who have sustained damage on the right side of their brain often remain surprisingly happy and positive regarding their situation, even though they might have sustained severe brain injury. It appears that the left side of their brain happily takes over and puts a positive spin on everything, regardless of whether or not such optimism is warranted. Many times, such patients are so optimistic that they refuse to recognize diminished capacity at all. In some cases, patients suffering from paralysis as a result of the stroke refuse to acknowledge the fact that they have lost any voluntary control of their body.

The Grim Realist (Right)

The right side of the brain is responsible for recognizing the negative aspects of a situation. Frequently, stroke victims who sustain damage on the left side of their brain view their situation as more dire than it is. Such patients are the opposite of hyper-optimistic stroke victims and tend to view their experience in an extraordinarily fearful and grief-stricken manner.

Most of us, with our fully functional hemispheres and corpus callosum, rely on the two halves of our mind to keep our sense of perspective balanced. We're aware that the glass is both half-empty and half-full, and we can evaluate the situation with that in mind. This balanced perspective allows for practical and reasonable identification of problems and the optimism to handle such problems without falling to pieces.

Emotion and Drug Addiction are tightly and inextricably connected. The high created by recreational drugs attracts users for a multitude of reasons, including personal experimentation and misguided attempts to self-medicate in the face of a mood disorder. Unfortunately, the high created by these recreational drugs alters the user's brain chemistry in such a way that the user becomes dependent on the drug in order to maintain any internal sense of emotional well-being. In other words, the user becomes addicted to the drug. Unfortunately, drug addiction is often viewed only in the criminal sense and drug users as law-breakers who are too lazy or too "bad" to just "kick the habit." Drug addiction is, in every sense, a mental illness and warrants treatment as such. Where criminal sentences alone possibly serve to curb the stream of illegal drugs, criminal sentences without medical treatment programs will do little to curb the demand for such substances.

Chemical Cause and Effect
We will now look at a few highly addictive recreational drugs and how they affect the brain.

Amphetamines are stimulants that cause the release of dopamine and noradrenaline. Long-term use could cause the nerve cells that generate these neurotransmitters to "burn out" and thus cause chronic depression.

Cocaine works by blocking the mechanisms that get rid of excess dopamine, serotonin, and noradrenaline. The user experiences feelings of euphoria, confidence, and energy (frequently nervous, manic-type energy). Without the drug, the user falls victim to extreme nervousness, depression, and lack of self-esteem.

Morphine and heroin are both highly active drugs made from the opium plant. Opiates work by creating a dopamine rush. Opiates bind to the receptors normally used by your natural endorphins. All addictive drugs negatively affect the receptors that they bind to by making those receptors less sensitive. This creates two problems.

It creates the problem of addiction because the desensitized receptors won't respond to the levels of the natural neurotransmitter for which they were intended. The user actually ends up "needing" the drug to get those receptors to work.

Desensitization creates the problem known as tolerance. As the user's receptors become less sensitive, the dose the user must take for the drug to work increases. Often users become so tolerant to a substance that they have to take extremely high doses of that drug in order to feel its emotional effects. Frequently, such doses are toxic and result in death.

Lesson Summary

Historically, Western society has shown a tendency to describe emotion in negative terms. Emotion is frequently viewed as the black sheep of human consciousness and many frown on emotional expressiveness. People who express their feelings openly are often labelled as weak, irrational, or hysterical. Young children, boys more so than girls, are often chastised for expressing grief, sadness, or pain. Although a certain degree of emotional control is an important social skill, and a hallmark of maturity, the notion that emotion is irrational, primitive, and detrimental to our well-being is way off the mark.

Lesson 5: Memory

One of the unique features of human memory is that it's selective. While the notion of remembering everything you've ever done or encountered might sound good, the reality of such a situation would surely be the acquisition of a lot of marginally useful information. So how does your brain select which experiences and information to maintain sharply and which to let fade? Your mind does this through the use and processing of what is commonly referred to as short-term memory. The destiny of a short-term memory depends heavily upon the emotions that the information evoked and how often the information is or was encountered. The hippocampus plays a major role in memory. Evidence indicates that most short-term memories are stored and processed by the hippocampus. It determines which memories are sent to the cortex for long-term storage and which are allowed to fade. In other words, the hippocampus is responsible for the transition from short-term to long-term memory.

Memory and Trauma

Beware that particularly traumatic experiences could skip the hippocampus and jump directly to the amygdala. Such memories are unconscious; the individual storing them is unaware of their presence. Scientists believe amygdaloid memories are responsible for phobias and post-traumatic stress syndromes. For example, suppose a child accidentally puts her hand on a hot burner and receives a rather painful and nasty burn. If this experience is particularly upsetting to the child, this memory might be stored in the amygdala and resurface as an inexplicable fear of burns or being burned.

Memory and Emotion

Now suppose the same thing happens, but the experience was unpleasant rather than catastrophic in the child's mind. The child experiences pain and fear and learns not to touch burners. That burners are dangerous registers quickly in the child's long-term memory, due to the emotional stress caused by the burn and the fact that this information directly affects the child's survival.

The emotional component of memory is the reason why, much to many parents' frustration, lessons "learned the hard way" register more clearly in children's minds than warnings or admonishments. Many times such warnings rattle around in a child's short-term memory briefly before fading away to a subtle glimmer of remembrance. Does all of this mean that parental warnings are useless? Hardly. The issues surrounding short-term memory simply indicate that such warnings bear repeating. Parents might sound like broken records, but their children's safety depends on a certain amount of "nagging." Information in our short-term memory that gets used frequently or is repeated often will eventually become part of our long-term memory store.

When most people think of cherished memories, they are thinking of long-term memories. Long-term memories are those memories that your brain has determined are important enough to warrant a longer shelf life. It's important to understand that there are different kinds of long-term memories and that long-term memories often have several different components.

Instinctive Memories

Scientists often think of instincts as genetically coded memories. Instincts are stored in the caudate nucleus and generally stick with you for life. For example, people typically will jump, startled, when they hear a loud, sudden noise.

Fear Memories

Particularly traumatic experiences could create fear memories. These memories are memories that are stored in the amygdala. People with such memories aren't aware that they have them. Scientists believe fear memories are responsible for phobias and post-traumatic stress disorders.

Procedural Memory

When you repeat a motion many times, the memory of that motion is stored in the putamen and cerebellum. The memory of how to ride a bike is stored in these areas. This is why certain activities seem to become automatic with enough practice.

Episodic Memories are personal, film-like memories that represent past experiences. The elements of episodic memories are stored in various parts of the cortex and then retrieved, and organized, by the frontal lobes. For example, how something looked is stored in the visual cortex, whereas how something smelled is stored elsewhere. When reconstructing the memory, the frontal cortex connects both elements together. The reconstruction process is part of the reason why we sometimes confuse facts. We possibly might construct a visual image of what happened more frequently than say, the sounds that occurred. As such, our recollection of what was heard will eventually be sketchier than our recollection of what we saw. Memories that are reconstructed infrequently tend to be forgotten.

"False" Memories: Are They Real?

False memories do exist. They are memories that are constructed based on the power of suggestion or the embellishment of real memories that are "foggy." Studies involving patients suffering from false memories indicate that while you might "think" the experience was real, your brain "knows" better. PET scans demonstrated that the "false" memories were generated exclusively in the frontal lobes, not in the temporal lobes where "real" memories lie.

Semantic Memory

Semantic memories are facts that are stored in the temporal lobe. For example, knowing that the president lives in the White House is a semantic memory. Semantic memories differ from episodic memories in that they are independent of a person's past.

Memory Loss

Abnormal memory loss can result from many different causes, such as emotional trauma, physical trauma, or disease, and it varies in severity. The most common causes for abnormal memory loss are: Alzheimer's disease, encephalitis, head trauma, emotional trauma, seizures, alcohol abuse, temporal lobe or hippocampal surgery, general anesthesia, and barbiturate use.

Alzheimer's Disease

Alzheimer's disease is a devastating illness that scientists are still working to find out what causes this disorder. So far it looks like there are several factors that could play a role in the progression of Alzheimer's.

A shortage of certain neurotransmitters (acetylcholine, somatostatin, and norepinephrine) has been connected to the disorder. Some evidence indicates that exposure to certain metals like aluminum and manganese plays a role. Connections to Protein Fragment Is Being Studied. Another element implicated in Alzheimer's disease is an essential protein called APP, or amyloid precursor protein. The brain can process APP in one of two ways:

One process produces protein fragments that are safely secreted from brain cells.

The other process produces an insoluble protein fragment, beta amyloid, a major component of the brain plaques that are a hallmark of Alzheimer's disease. The accumulation of beta amyloid between neurons blocks communication and contributes to the eventual death of the cell, especially in regions of the brain that play a role in the formation of memories (such as the hippocampus).

APP is in a class of proteins (called cell adhesion molecules) involved with the switch from short-term to long-term memory. Current drug therapy to treat Alzheimer's boosts the function of neurotransmitters that are otherwise lost to the progression of the disease. However, it's becoming apparent that the deficit might not be in the transmitters but rather in the cell adhesion molecules. Early evidence shows that a number of steroid hormones and a class of drugs known as cognitive enhancers might correct this "sticky" problem and prevent it, too.

Encephalitis

Encephalitis is the inflammation of the brain and spinal cord. This problem can result from many different diseases, including rabies, polio, the flu, scarlet fever, and even AIDS. While there is no treatment for encephalitis, there are, in many cases, vaccines that prevent infection. In most cases the symptoms of the illness are mild and include fever, headache, body aches, skin rash, and swollen lymph glands. In severe cases the illness can cause headache, high fever, neck stiffness, stupor, and disorientation with coma, tremors, convulsions, paralysis, and occasionally death. The type of memory loss experienced by encephalitis survivors depends largely upon what parts of their brains were damaged by infection-induced swelling.

Seizures

Seizures are caused by rapid, uncontrolled electrical activity in the brain and can result in brain damage that causes memory loss. Seizures can result from a host of causes, from epilepsy to drug overdose to high blood sugar (as seen in diabetics). Many people with brain tumours also experience seizures. Not all seizures result in memory loss; however, if it does, the type of memory loss (short- or long-term, temporary or permanent) depends on what part of the brain the seizures occur in. For some patients, particularly those suffering from epilepsy, medication will control or reduce incidents of seizures and therefore reduce the risk of brain damage and memory loss.

Alcohol Abuse

Alcohol abuse can result in Korsakoff's syndrome. This disorder results from a thiamin deficiency seen often in alcoholics and involves memory loss and cognitive problems. Sufferers experience difficulty solving problems and learning. The most distinguishing symptom is confabulation (fabrication), where the person makes up detailed, believable stories about experiences or situations to cover the gaps in the memory.

Brain Surgery

Brain surgery involving the temporal lobe generally causes the loss of long-term memories, whereas surgery involving the hippocampus involves the loss of short-term memories and the ability to create new long-term memories. Time effectively stops for a person without a functioning hippocampus.

Summary

Our pasts are an integral part of our identity and ability to function. The skills, education, and emotional experiences stored in our memory serve as the backdrop onto which we paint our sense of self. Our memories provide us with a frame of reference: They allow us to distinguish past from present, landmarks and locations, people and relationships.

Lesson 6: The Self (You)

Language and culture play an important role in the development of our minds and how we perceive the world. It's important to understand that, in most cases, language and culture are inextricably connected. How exactly do these constructs relate to our perception of self and others? Recent evidence indicates that the awareness of self, the knowledge that you are a separate and independent being, is not dependent on culture or language. This contradicts earlier theories that held that the perception of self is entirely dependent on the development of language. However, the development of identity, or the social self, appears entirely dependent on both language and culture. Let us explore the influences that language and culture have on our brains and thought patterns.

Language Development

Most human beings speak in one manner or another. However, it appears that children, if not exposed to language by a certain age, will lose the ability to learn important language skills. The evidence for this is based on research involving so-called "feral" or "wild" children. Recorded incidences of such children are rare. In most known cases, it's apparent that many of these children came to this state as a result of neglect and abuse. One of the more famous cases is that of Genie, a young girl who was found at the age of 13 after spending most of her life tied to a chair. Despite Genie's rescue from this dire state in 1970, she has been unable to grasp the significance of syntax (grammar). She has, however, made increasing improvements in semantics and now has an extensive vocabulary. Thus it appears that the introduction of syntax must come during the early years, but that the ability to learn new words continues through adult life.

Subsequent brain scans revealed that Genie uses the right side of her brain when she speaks. This in itself is not remarkable, given that the language centre is located in the right brain in 5 percent of the population (mostly left-handed people). What's unusual is that Genie does this, not because her language centre developed in the right hemisphere, but because her language centre (located in the left hemisphere), deprived of the sound of human speech, had atrophied. The part of the brain she uses now for language is normally reserved for environmental sounds. Researchers believe that area of her brain remained active as a result of hearing distant noises such as birds singing, the bathroom next door, floorboards creaking, and so on.

Language and Thought

So how does our use of language affect the manner in which we think? Most people find that their mind quickly translates their thoughts from images into words. Do people who speak different languages think differently? This has been a subject of debate between anthropologists, linguists, biologists, and neuroscientists for years.

Recent evidence indicates some aspects of thought are affected by language, but that most thought processes remain the same across cultural lines. Some of the most compelling evidence showing the influence of language on thought has been produced by Stephen C. Levinson at the Max Planck Institute for Psycholinguistics in The Netherlands. Levinson and his colleagues have studied the differences between the speakers of languages that describe spatial relations in terms of the body (like English) and those that use elements of their environment (like some Aboriginal Australian languages). For example, English-speaking people would refer to their right or left arm. Australian Aborigines would refer to their north/south/west/east arm, depending on which direction they were facing. In order to speak using the Aboriginal language, a speaker must be aware of where he or she is in relation to the four compass points at all times. Levinson's work has shown, in extensive cross-linguistic and cross-cultural studies, that Aborigines are indeed aware of the four compass points at all times.

Identity

When most people are asked to identify themselves, they frequently do so within the constructs of their religion, nationality, ethnicity, language, or job. These cultural components are a major part of most people's identity. Thus, many people perceive threats to these cultural constructs as threats to who they are. The issues for people concerned by threats to their "way of life" are not changes in day-to-day living, but challenges to their identity. We rely on our identities to understand relationships within our social group and the world at large. The creation of identity goes beyond the awareness of self. Self-awareness is the knowledge that you are a person, separate and distinct from other people or objects. Identity is a construct that you build, using tools provided by your culture, language, and family, to create a social self.

The Difference Between Identity and Self-Awareness

Your identity is the perception of who you are; self-awareness is the knowledge that you are. Some aspects of your identity you create yourself -- your career choice, for example -- and some aspects of your identity are based on your experiences and, as such, depend on your memory. There are some aspects of identity that are beyond your control, such as your gender, skin colour, and age. The level of self-determined identity is dependent on the number of prescribed roles in a society and the rigidity with which a society expects individuals to conform to those roles. Identity and self-awareness can also be thought of in terms of the autobiographical self and the core self.

Core Self/Core Consciousness

There are two main types of consciousness and two types of selves. Core consciousness is a "sense of self about one moment -- now -- and about one place -- here." Thus, the core self is a "transient entity, ceaselessly re-created for each and every object with which the brain interacts." Core consciousness is stable across the lifetime of an organism, and it's not exclusively human. Core consciousness is image-based, not language-based, and is firmly grounded in the present, unlike extended consciousness and the autobiographical self.

Autobiographical Self/Extended Consciousness

In extended consciousness, "Both the past and the anticipated future are sensed along with the here and now in a sweeping vista as far-ranging as that of an epic novel."

Our traditional sense of self, called autobiographical self, contrasts with the core self in that it "corresponds to a nontransient collection of unique facts and ways of being which characterize a person." This organized record of that collection the autobiographical memory. Unlike core consciousness, extended consciousness (which is dependent on working memory, reasoning, and language) evolves over a lifetime.

The two kinds of self are related to each other and interrelated to the two kinds of consciousness. The autobiographical self needs the core self and core consciousness in order to develop. The core self and core consciousness can exist without the autobiographical self and extended consciousness; however, the reverse isn't possible. Furthermore, emotion is neurologically connected to both consciousness and our physical body, weaving an intricate network that we call Self!

Identity Problems

There are a host of conditions that can cause identity problems. These conditions include memory loss, dissociative identity disorder (multiple personality disorder), and oppressive social practices.

Memory Loss

Since our identities depend in large part on our experience, memory loss can cause significant damage to our sense of who we are. The extent of the damage depends on what kind of memory loss is sustained. Individuals could forget experiences before or after a certain time, lose the ability to recognize faces, forget their name or family history, or experience difficulty with many other memory-dependent elements of their identity. These types of events can be catastrophic to a person's identity and often result in a great deal of stress for the affected individual. For example, when Jerry Garcia of the Grateful Dead sustained memory loss due to complications resulting from drug abuse, he forgot how to play the guitar. Garcia, after the memory loss, was no longer able to identify himself as a guitar player since he no longer possessed that particular skill. Fortunately for Garcia (and Grateful Dead fans), he later relearned how to play his chosen instrument.

Dissociative Identity Disorder

Films like Sybil have made the public fascinated with dissociative identity disorder (DID), more commonly known as multiple personality disorder. Some controversy regarding this disorder exists, as some psychologists question whether DID is a real condition. DID is characterized by the presence of two or more separate identities that control a person's actions and behaviour. People with DID frequently experience gaps in memory that are more significant than ordinary forgetfulness. DID is closely connected to trauma and post-traumatic stress disorder. Many people diagnosed with DID lead functional and successful lives and challenge the notion that their condition is maladaptive. Much controversy exists regarding how DID should be handled and treated. Some practitioners feel that treatment should entail merging all existing personalities into one, while others disagree and feel that DID patients should be taught how to live successfully with all of their separate identities.

Summary

The brain is closely connected to our sense of self. You are aware that there is a person (you) that is distinct and independent of other humans and objects. This mind object is the Self. How you define the relationship between you and your environment determines your identity. The development of your identity is closely linked to your language, culture, and family.

Lesson 7: Brain Trauma and Injury

Split-Brain Patients:

People who have had their corpus callosum severed, either surgically or due to an accident, are called split-brain patients. As mentioned earlier in this course, the corpus callosum is a group of nerves that allow the two sides of your brain to communicate with each other. Severing the corpus callosum ends this communication. Research involving split-brain patients has shown that the two sides of our brain might not only experience emotion differently, but could even have different desires and motivations.

Take for example, the case of P.S., a patient of Michael Gazzaniga of the University of California. P.S. was a split-brain patient who had enough language ability in his right hemisphere (remember the brain's language centre is located in the left hemisphere) to spell out words, using Scrabble letters, with his left hand. (Generally, the left side of the brain controls the right side of the body, and vice-versa.) Gazzaniga designed an experiment where P.S. was asked a series of questions that were first registered by his left hemisphere only and then registered by the right hemisphere only. These questions required that P.S. evaluate many things including foods, colours, and his girlfriend's name.

Gazzaniga discovered that P.S.'s right hemisphere viewed these things more negatively and rated them less highly than his left hemisphere. Furthermore, when P.S.'s left hemisphere was asked what he wanted to do when he graduated, it replied that he wanted to become a draftsman. When the same question was posed to his right hemisphere, it replied that he wanted to become a race car driver!

Alien Hand

Alien hand is an unusual phenomenon that affects some split-brain patients. It's characterized by a patient's inability to voluntarily control one -- usually their non-dominant -- hand. Patients experiencing alien hand might open a door, only to have the other hand shut it. One woman had difficulty getting dressed in the morning because she would choose one outfit to wear and her "alien hand" would grab another. While this might seem comical to those of us not experiencing the condition, witness Steve Martin's character in the film All of Me -- the inability to control one's own body is quite distressing and can be frightening. One man told of reaching out to hug his wife with his right hand, only to watch his left hand knock her flat. Another man feared that his alien hand would strangle him in his sleep. It's important to understand that alien hands only occasionally do anything dangerous; typically, they're more of an annoyance.

Some scientists speculate that alien hand is what happens when the right hemisphere realizes that there is a task being done and finds some way to participate. This is similar in some ways to the confabulation that some memory loss patients engage in. In those cases, the fantastic tales that are woven serve to fill gaps in memory. In the case of alien hand, the strange and often counterproductive antics of the alien hand serve to fill information gaps regarding motor function. Other researchers believe that alien hand is the result of two separate spheres of consciousness. They believe that cutting the line of communication between the hemispheres literally prevents the left hand from knowing what the right hand is doing. As a result, the left hand simply does what it wants.

Who's correct? There is evidence to support both arguments, so scientists will have to do more research to find the answer. Perhaps both ideas are correct to some extent.

Traumatic Brain Injury:
When people usually think of brain damage, they envision reduced intellectual ability or children with developmental disorders. While brain damage can cause both situations, traumatic brain injury can affect personality without damaging intellectual capacity.

For example, one woman who underwent brain surgery to remove a tumour literally lost her sense of humour after the operation. While this woman's cognitive and intellectual abilities remained the same, she completely lost her sense of mirth.

A classic case of personality change resulting from a traumatic brain injury is that of Phineas Gage, a 19th-century rail worker who experienced the misfortune of having a steel rod sent through the front part of his head. Gage survived the incident, but was forever changed. Formerly a purposeful, industrious person, Gage became a flighty, impulsive, and rude character. His intellectual abilities remained sharp, but he became disabled by his lack of inhibitions. In 1994, Hanna and Antonio Damasio examined Gage's skull and the rod that changed his personality so dramatically. They determined that the rod had seriously damaged both of Gage's frontal lobes, particularly a region of the left frontal lobe called the ventromedial region. This finding agreed with information obtained from modern-day patients suffering from similar brain damage. Patients with such damage are able to remember factual information and perform mathematical computation, but they're unable to keep promises, honour commitments, keep a job, or succeed in marriage. They lose the ability to plan for the future or to understand how their behaviour affects themselves and others.

Does this mean that all hostile, nasty, rude, and impulsive people suffer from brain injury of some sort? Not necessarily. Their behaviour could be the result of environmental and cultural factors. They might have had experiences that encouraged hostility as a survival mechanism. What you consider rude might be considered acceptable in someone else's family or culture. Though we are our minds, it's important to understand that variety is part of nature, and differences in mental function or behaviour aren't necessarily pathological. Nonetheless, sometimes, antisocial behaviour is pathological, and new advances in brain disorder treatment offer possible ways to alter such behaviour.

Adapting to Brain Injury

Although the damage caused by traumatic brain injury (TBI) is often permanent, the degree to which this damage affects a person's quality of life depends on many factors and, in many cases, can be lessened through changes in lifestyle and behaviour. Common problems that challenge people recovering from traumatic brain injury include memory loss, headaches, organizational problems, difficulty sleeping, frustration, depression, and speech difficulties. One of the most important aspects of dealing with a brain injury is consulting with a professional trained to deal specifically with this condition. Doing so can provide a TBI patient with valuable information, alleviate frustration, and clarify what lifestyle changes will help most.

Split-brain patients are patients whose corpus callosum, the connection between the left and right side of the brain, have been severed for one reason or another, In these patients, the two sides of the brain are unable to communicate with each other. Research has indicated that these two halves of your brain might not only experience emotion differently, but could even have different desires and motivations. Individuals suffering from traumatic brain injuries (TBI) have done much to increase our understanding of how the human mind works. Such cases serve to illustrate that our personalities and perceptions depend entirely on our minds. Despite this, there are many cases in which the effects of traumatic brain injury can be lessened through changes in lifestyle and behaviour.

Lesson 8: Your Evolving Mind

Why did humans become self-aware? In order to understand human self-awareness and consciousness, it is helpful to first examine evolution. Evolution is the change in the genetic makeup of a population. Over long periods of time, these changes can result in the emergence of new species due to a process called natural selection.

The action of natural selection relies on the subtle genetic variations within a population. For example, suppose a population is stricken with a bacterial plague, and a certain segment of that population carries one or more genes that protect them from the epidemic. These individuals are more likely to survive the plague than individuals lacking such protection. After the plague, future generations would likely inherit this genetic protection, making the population as a whole less susceptible to this threat. This process doesn't mean that the protected individuals were better than, or superior to, the rest of the population, only that they were better equipped to battle one particular threat.

The Expansion of the Human Mind

Human beings, or Homo sapiens, are characterized largely by our self-awareness. Our species name means "thinking man." It's no surprise that greater reasoning abilities increase an individual's -- human or otherwise -- capacity to adapt and survive. With that in mind, you shouldn't be surprised to hear that evolutionary pressures favoured mammals with larger brains and that all mammals experienced an increase in brain size after the dinosaurs went extinct. Now, before we get into a discussion of brain size as it relates to intelligence, we must talk about encephalization.

Encephalization is a measure of brain size in relation to overall body size. For example, elephants have a larger brain than humans, but we have a larger brain in proportion to our body size. So, although brain size is a factor in determining intelligence, it certainly isn't the only factor that you must consider. We are more intelligent than elephants -- despite our smaller brain size -- because we are more encephalized.

During the period following the dinosaurs' extinction, mammals (and birds) replaced reptiles as the dominant land-based vertebrates. Mammals were selected for larger brains, and over time, the mammalian neocortex enlarged significantly. The neocortex is the outer portion of the cerebrum and is associated with higher brain functions. The mammalian neocortex expanded so much that it now comprises the largest segment of the mammalian brain. The construction of such a highly developed brain requires more time at the neonatal level. This is why the gestation period for mammals exhibiting the most complex brain development is normally much longer than other animals. Scientists speculate that a longer gestation period for primates is not a recent development. Fossil evidence shows that primates have always been large-brained mammals -- ancient primates had brains that were twice as encephalized as other land mammals. This still holds true for living monkeys and apes. So where do humans fit into all of this?

About five million years ago the trend towards increased encephalization ceased for all mammals except early humans. For some reason encephalization in early humans continued after this process had died down in all other species. What elements of the early human environment were responsible for this? After all, our current brain size is three times that of Austoalpithecus afarensis (one of our early ancestors), and this extra brain matter is what makes us who we are!

About 50,000 to 100,000 years ago early humans developed brains that were the same size as ours. This is long before early humans engaged in regular tool use. So what caused the environmental demand for an increase in brain size? Most scientists agree that increased socialization played a critical role. Primates that live in large social groups usually have larger brains (in proportion to body size) than primates that live in smaller groups. Similarly, the increase in human brain size might have resulted from the demand to survive as part of a larger group. The abilities to communicate and remember group members and events would have been important for the group's survival. However, some scientists feel that other factors besides increased socialization played a critical role in human brain expansion.

After all, chimpanzees and gorillas live in complex social settings, and their brain size didn't undergo the increase witnessed in humans. Many scientists feel that increased socialization and dietary changes resulted in our brain expansion. Fossil evidence indicates that about 2.5 million years ago, early humans started eating a lot more animal matter. This provided our ancestors with more protein, which could explain the increase in body size that early humans experienced. More importantly, carcass fats provided a source of certain ready-formed polyunsaturated fatty acids (PUFAs), specifically AA, DTA, and DHA. These three long-chain PUFAs together comprise more than 90 percent of the structurally important and biochemically active fat found in the brain. So, the combination of increased social activity paired with the raw materials for "brain building" might be what caused humans to become such brainiacs.

Notions of Superiority

The history of brain science is fraught with bigotry and notions of ethnic and racial superiority. When discussing the brain and brain function, it becomes increasingly important that you're aware of such misconceptions and don't fall prey to them. Sexism and racism have underscored a large degree of brain research, and books like The Bell Curve show that such thinking continues to thrive.

Samuel G. Morton, a well-respected 19th-century physician from Philadelphia, created a racial hierarchy based on the cranial capacity of various ethnic groups. Like his contemporaries, Morton equated brain size with intelligence. He concluded that Anglo-Saxons and Teutons were the most intelligent, followed by Jews, Hindus, Native Americans, and blacks. Morton considered himself an objective scientist, and his measurements were performed accurately. Morton's erroneous conclusions were largely based on popular assumptions and the fact that he did not account for body size, age, or gender. Morton's work was reprinted many times to justify immoral and oppressive social practices.

Paul Broca, a well-respected 19th-century scientist, countered the assertion that women's brains were smaller simply because women were smaller by stating that "the relatively small size of the female brain depends in part upon her physical inferiority and in part upon her intellectual inferiority." Similarly, Gustave Le Bon, the father of social psychology, wrote that "Women, whose brains are closer in size to those of gorillas ... represent the most inferior forms of human evolution and are closer to children and savages than to an adult, civilized man." The work of Broca and Le Bon was used to justify the erroneous notions that women only exist for childbearing/rearing purposes, that women are irrational, and that women are too immature to handle money or property wisely. Their research was biased and served, in many ways, to bolster an unjust social system in which educated white men, like themselves, were on the top. Many women's and civil rights activists have criticized recent research into brain-based sex differences, fearing similar bias and bad science. Since sexism still pervades our culture, such fears are not unwarranted and scientists engaging in such research carry a very weighty responsibility to ensure that their work is not misinterpreted.

Although modern humans have less upper body strength, are bipedal, and have less visible hair than other primates, the most startling difference between us and our wilder brethren is our intelligence and self-awareness. An individual's intelligence depends on both environmental and biological factors, but the vast majority of humans are self-aware. The capacity to learn, the plasticity of the human mind, and the notion of Self are things that have evolved over time.

Well done – you have reached the end of this brief introduction to the workings of your brain and how it creates your identity. I hope you will want to continue your studies of psychology through the many books in your local library or by surfing the web.

Wishing you luck in all your future endeavors!