UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

BRAIN PLASTICITY AND THE HELPING PROFESSIONS

A THESIS

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

Degree of

MASTER OF HUMAN RELATIONS

By

HIND ALSADAH
Norman, Oklahoma
2012

BRAIN PLASTICITY AND THE HELPING PROFESSIONS

A THESIS APPROVED FOR THE
DEPARTMENT OF HUMAN RELATIONS

BY

[redacted]

Table of Contents

List of Figures

Abstract

The purpose of this paper is to contribute to more understanding of brain plasticity and its application in human relations. The paper includes a literature review which explains the background and the roots of the subject and explains evolving views on how the brain functions. Descriptions are given on how the brain and the central nervous system work and implications of brain plasticity are shown in case examples. The argument is made that human relations practitioners can help clients better by knowing about the possibilities of brain plasticity.

Chapter 1: Introduction

Overview of Study

Brain plasticity is the brain's ability to reorganize itself so that when one area of the brain is damaged, other areas of the brain can take over its job and function (Schaffer, 2007, p. 61).

The main point of this thesis is to learn how to apply brain plasticity in counseling and other psychotherapies. Adding an understanding of brain plasticity to a counselor's knowledge base will result in a more effective way to solve many problems. In addition, it is critical to educate people during counseling and psychotherapy sessions about their natural miracles, "their brains". Plus, brain plasticity has allowed many people in the community (such as old people, children, and families) to return to a normal function following damage, disease or trauma.

The research in this thesis will include a literature review that explains how the theory of brain plasticity has developed over the years. Also, the thesis will include a simplified description of the nervous system and how the brain works in order to make it easier to understand brain plasticity. After that, the details of how to apply brain plasticity in different domains will be discussed. Lastly, some key findings, and true stories will be added.

Literature Review

The origins of the concept of brain plasticity will be displayed using a historical review of localization, or more specifically (cerebral localization), which is one of the theories on how the brain works (Doidge, 2007, p. 16). Having the knowledge of what localization is should make it easier to understand brain plasticity. Localization theory is the idea that each part of the brain is responsible for a specific function (Sabbatini R., 2002). So, if any damage happens to one area, no other part of the brain can do the function for that damaged part and nothing can be done (Doidge, 2007, pp. 12, 17). Localization theory was pioneered by Franz Joseph Gall, who divided the brain into 37 areas (Sabbatini R., 2002, Tizard, 1959). None of the areas that Gall specified for a particular function are related with their real functions, although Gall's contribution to the neuroscience is unforgettable (Morgan, 1995). Jean Baptiste Bouillaud and Ernest Auburtin were strong believers in Gall's localization (Morgan, 1995, Stookey, 1954). Also Paul Broca was influenced by Gall's localization theory in his discovery of an area of the brain that is responsible for speech (Morgan, 1995).That discovery is considered one of the most important clinical discoveries in the history of localization theory (Morgan, 1995).

Localization theory has been through three developmental stages. The first stage was in the second century and focused on the brain as the location of the soul (Morgan, 1995). The Greeks thought that the soul was placed in the heart, head and liver. But the part of the soul that related to intellectual capacity was placed in the head. The great anatomist Galen had great influence on this stage by showing experimental evidence that the brain was the center of the nervous system and was responsible for motion, thinking and sensation. The second stage of localization theory (2nd - 18th century) focused on the cognitive functions of the brain. During the 18th century, it was concluded that intellectual functions are localized in the brain. The third stage was initiated in the 19th century and continues until now. It has been focusing on how cognitive activities are organized in the brain (Morgan, 1995).

Over time then, scientists who believe in localization theory have focused on the intellect as part of the soul, cognitive functions of the brain's capacity to organize cognitive activities. The beginning of the transformation localization theory to brain plasticity started with Paul Bach -Y- Rita, a neuroscientist who was a localizationist himself until the 1960s (Doidge, 2007, pp. 16-17). He joined a scientific group in Germany that was studying how vision works in a cat. They found that the visual area of the cat's brain was altering two other areas that were known to activate sound and touch (Doidge, 2007, p. 17). Paul - Y - Rita concluded after that experience that one of the central principles of the localization theory - one location, one function - was not right (Doidge, 2007, p. 17). The result of the cat experiment matched with Vernon Mountcastle discovery that the three areas of visual, auditory, and sensory cortices have the same six layer processing structure (Doidge, 2007, p. 18). In other words, the visual, auditory, and sensory cortices are not specialized. That's mean whatever signals are sent to it, the brain's cortex should be able to read it and process it (Doidge, 2007, p. 18).

After that, Paul - Y- Rita attempted to study exceptions about traditional understanding of localization and found that Paul Broca never denied the idea of plasticity (Doidge, 2007, p. 18). Also, in the 1820s, Pierre Flourens "showed that the brain could reorganize itself" (Doidge, 2007, p. 18). Based on the literature that supports the exceptions that Paul - Y - Rita discussed, in 1824, Pierre Flourens suggested that "As long as not too many of the loops are removed, they may in due time regain the exercise of their functions" (Tizard, 1959). Flourens concluded that "behavior could not be localized to specific cortical regions" (Marshall, 1984). In 1923, Karl Lashley stated that there is a "plasticity of neural function" (Kajer, 2010).

Paul - Y - Rita, however, went further in his theorizing about the brain when he rejected the idea of localization. Instead of localization, he believed that the brain is adaptable and one of the brain's areas can do the function if any damage happens to another area, a process he called "sensory substitution" (Doidge, 2007, p. 13). Based on his theory in 1969, he made a machine called the "tactile-vision device" that helped some people who were blind from birth to see and it worked (Doidge, 2007, p. 10). The "tactile-vision device" consisted of a dentist chair, wires, and computers (Doidge, 2007, p. 10). The camera scanned an image in front of the patient and sent it to the computer which analyzed the image (Doidge, 2007, p. 11). Then, the computer sent electrical signals to a metal plate with vibrating stimulators, placed at the back of the patient with direct contact on the skin (Doidge, 2007, p. 11). The stimulators would vibrate for the dark part of the image and would maintain position for the brighter part of the image; this allowed the patient to read and observe a glimpse of the nearby objects (Doidge, 2007, p. 11)

In the 1960s, David Hubel and Torsten Wiesel discovered that a kitten's brain in a critical period of development is very plastic (Doidge, 2007, p. 51, Hubel & Wiesel, 1970). They also discovered that the infant's brain is similarly, plastic (Doidge, 2007, p. 52). The critical period is the sensitive developmental stage for the brain in a very early age. When the brain is being very plastic, it allows any early experiments to reshape it and reorganize it. The period of greatest brain plasticity in human starts from birth to 8 - 10 years (Doidge, 2007, p. 78, Hubel & Wiesel, 1970).

The critical period is the best window of opportunity to learn. That is interpreted as why children learn more quickly than adults and why they pick up new languages and learn skills, such as playing a musical instrument so fast (Johnston, 2009). Also, children have a greater recovery rate from a brain injury than adults (Hocking & Horton, 1997). Victor Nadler also found that a greater degree of brain plasticity can be reached if an injury is treated at a very early stage of postnatal development (Scheff, 2003). The good news is that brain plasticity is not exclusive in children. Adults also can enjoy the benefits of their brain plasticity. There are many true examples of the benefits of brain plasticity in adults that will be displayed later.

The fact that the brain is adaptive and reorganizes itself requires special attention to a few factors that can help to improve the brain's capacity to achieve plasticity. Two of the most effective factors in promoting brain plasticity are early experiments that stimulate brain activity and enriched environments (Kolb, Gibb, & Robinson, 2003, Murphy & Corbett, 2009). Early experiments are so critical because the brain in the critical period is extremely sensitive to any changes in the environment and these changes can strengthen or weaken the neural connections (Johansson, 2004, Mercado III, 2008). Neurons are nerve cells (Arden, 2010, p. 3); and neural connections mean the communication between neurons is through the brain's chemicals that are called neurotransmitters (Arden, 2010, p. 7). Also, parental experiences in early age alter brain's neural connections (Kolb, Gibb, & Robinson, 2003). An explanation for this phenomenon is that the experiences in early age are more effective than older ages because children's brains are twice as active as adult's brains (Curtis & O'Hagan, 2008, p. 28, Kolb, Gibb, & Robinson, 2003). During childhood, the brain is quite plastic and so sensitive to the emotional experiences (Steinberg, Vandell, & Bornstein, 2010, p. 202). Others factors that help improve brain plasticity are cognitive training, and physical exercises (Cramer, et al., 2011).

Brain plasticity has a wide area of applications in neurology, medicine, psychology, education and related fields. In the domain of neurology and medicine, as discussed before Paul-Y-Rita's invention of the "tactile-vision device" triggered the brain to adapt to help blind people to see. Also, brain plasticity has helped a wide range of people who have had a stroke to improve and recover (Murphy & Corbett, 2009). In the domain of education, we have a great example of Michael Merzenich, who designed "Fast ForWord," a program based on brain plasticity principles in order to help disabled children improve their skills in math and memory (Doidge, 2007, p. 47). In addition, brain plasticity can also be applied in psychotherapy and counseling. It was found that various forms of psychotherapy can permanently change the brain and can, thereby, be effective in treating anxiety disorders and fear (Friedman, 2002, Porto, Oliveira, Mari, Volchan, Figueira, & Ventura, 2009). In fact, cognitive-behavioral therapy is considered to be the most effective technique to treat anxiety in children and adolescents (Langelier & Connell, 2005) and can be explained through an understanding of brain plasticity as a way for new thoughts and new behaviors to trigger new, more adaptive brain responses.

Summaries of Recent Articles

Harnessing Neuroplasticity for Clinical Application

The article "Harnessing Neuroplasticity for Clinical Application" by Cramer, et al. (2011) is based on a workshop by 27 leading scientists who in 2009 endeavored to promote clinical treatments through research on neuroplasticity. The researchers define neuroplasticity as the nervous system's capacity to respond to extrinsic and intrinsic stimuli through structural reorganization, connections and functions. The scientists stated examples of clinical neuroplasticity; these include injuries such as spinal cord injury, stroke and trauma (Cramer, et al., 2011). Motor recovery after a stroke was studied, it indicted that when there is injury to the motor network, intra-hemispheric change occurs spontaneously. These changes are demonstrated by clinical symptoms such as dorsal shift of the hand area (Cramer, et al., 2011).

The studies found a relationship between neuroplasticity and clinical phenotypes which led to specific clinical assessment criteria and therapeutic interventions. For example adaptive or maladaptive neuroplasticity was related to clinical phenotypes such as addictive and mental disorders, stroke and neurotrauma (Cramer, et al., 2011). The application of neuroplasticity in clinical practice is also related to the findings that clinicians are able to measure brain plasticity which is induced by treatment after injury to the spinal cord. Negative implications of plasticity were also discovered by the scientists. These include onset of new epilepsy after trauma to the cerebral cortex (Cramer, et al., 2011). Furthermore, in clinical practice, the maladaptive expressions of plasticity include allodynia and chronic pain. Neuroplasticity is also significant in the treatment of neuropsychiatric, developmental and pediatric disorders. More importantly, brain simulation during clinical studies and understanding of neuropharmacology in clinical practice is related to neuroplasticity.

A Review of Human Brain Plasticity and Training Induced Learning

Green and Bavelier (2010) present an article "Exercising Your Brain: A Review of Human Brain Plasticity and Training Induced Learning" which demonstrates the capacity that human being have in learning new skills. The authors present learning as an adjunct of adapting to the environment. The article illustrates that the training regimens for rehabilitative and training paradigms have challenges in the effort to improve quality of life. The problems in learning various skills are the major impediments to the rehabilitative processes of training new behavior (Green and Bavelier, 2010). Learning has some specificity and thus perpetual learning demonstrates that human beings have the potential of improving their skills and learning new ideas. The learning abilities of human beings are explained in terms of the plasticity of human brain which has been traced to the motor domain of the brain (Green and Bavelier, 2010).

In both general learning and training regimens, human beings have ability to adapt to changes by acquiring new skills. Nonetheless, the mechanisms of human learning vary and thus they determine the success of training regimens. Research findings however reveal that there are abilities such as ability to speak and recognize faces which are embedded in the cognitive domain of human beings and thus they normally occur effortlessly. The complexity of the training regimens illustrate that there are various intrinsic and external determinants of learning and ability of transfer of knowledge (Green and Bavelier, 2010). These determinants include arousal to learn new ideas or skills and the motivation behind the learning process. These factors lead to variability in learning and the task difficulties which are experienced by various people.

Brain Plasticity in Health and Disease

Brain Plasticity in Health and Disease is an article by Johansson (2004) which reveals how learning, experience and response to lesions of the brain can modify the neuronal circuits in the brain as a result of plasticity. Imaging studies which studies the brain are described with a view of demonstrating the changes in neural circuits which occur during the adaptation of human beings to various changes within and externally in the environment. In studying brain plasticity, neuroimaging methods such as positron emission tomography (PET), Milliseconds in magnetoencephalography (MEG) and functional magnetic resonance (fMRI) are used (Johansson, 2004)

The development of the adult human brain and the associated plasticity has been found to be less significant as compared to the young brain during childhood development (Johansson, 2004). Nonetheless, there is maladaptive brain plasticity such as focal hand dystonia which have been found in adults and thus illustrating the role of magnetic imaging in investigating changes in the brain which would be indicative of maladaptive disorders (Johansson, 2004). It has been revealed by scientific findings that brain plasticity may emanate when an intact brain lacks sensory input. This is normally caused by lesions of peripheral nerves or amputation. In this regard, neuroimaging has demonstrated rapid remodeling of the brain cortex in cases of amputation and peripheral nerve lesions which block sensory input to an intact brain (Johansson, 2004).

Plasticity during Stroke Recovery

Murphy and Corbett (2009), present the article "Plasticity during Stroke Recovery: From Synapse to Behavior" with a view of demonstrating that there is brain plasticity during the process of recovering from stroke. Stroke is characterized by damaged brain neuronal networks which result from an extended reduction of the flow of blood to the brain. Recovery from stroke has been found to have increased strengthening of synapses and rewriting of brain neural activity which is dependent on the activities of the brain. It is therefore through investigations of the brain plasticity that recovery from stroke can be improved and the healing duration decreased significantly (Murphy and Corbett, 2009).

Scientific evidence reveals that the adult brain undergoes plasticity in efforts of retaining normalcy in functioning after a stroke (Murphy and Corbett, 2009). Recovery from stroke is described through functional recovery processes where after many years stroke patients experience positive change of brain function. In recovery from stroke, there is redundant and diffuse connectivity within the CNS in addition to the formation of functional and structural circuits within the brain (Murphy and Corbett, 2009). These are the two factors which have been found to contribute to the plasticity induced recovery from stroke. Additionally, recovery from stroke illustrates remaps of motor and sensory locations of the CNS which further show that plasticity plays a central role in recovery of individuals from stroke.

Motor Recovery after Early Brain Damage

"Motor Recovery after Early Brain Damage" is an article by Sabatini, et al., (1994) that explains through research how plasticity plays a leading role in recovery of individuals from damage of the brain which occurs early in life. Research and clinical findings have demonstrated that there is remarkable recovery of individual brains later in life regardless of the damage they experienced early in life. Through imaging scans and studies such as Emission Tomography, it has been revealed that the cortical areas of the brain hemisphere which is unaffected by the injury play a leading role in the plasticity and recovery of the affected hemisphere (Sabatini, et al., 1994).

A case report of a 31 year old white male reveals that regardless of the congenital cerebral malformations, plasticity enabled the patient to have his right cerebral hemisphere repaired and thus enabled re-normal movement of his limbs (Sabatini, et al., 1994). Through imaging techniques such as Positron Emission Tomography revealed that the unaffected hemisphere of the brain contributed to the development of the affected motor areas of the brain and thus the ability of the patient to recover from the damage of the brain which he experienced early in life (Sabatini, et al., 1994).

Research Method

The purpose of this literature review was to determine what the best ways to enhance and apply brain plasticity. This research is based on other scholars' quantitative and qualitative studies. The research was conducted through library sources, using various peer reviewed journal articles and books. The literature was not based on specific era. Some older articles were used to clarify more details for a historical review of the subject, while the more current articles were examples of current developments in the field of brain plasticity. All the articles were written in English.

Chapter 2: Nervous System and Brain Functions

The nervous system is in charge of supervising all other systems in the human body. The nervous system is divided into two components: the central nervous system (CNS) and the peripheral nervous system (PNS) (Doidge, 2007, p. 53, Swan, 2008, pp. 2-3). The central nervous system consists of the brain and the spinal cord, while the peripheral nervous system consists of a cluster of nerves that transport data from and to the CNS (Swan, 2008, p. 3). Neurons are considered to be the fundamental elements of the nervous system. They are the nerve cells. Each neuron is composed of a cell body, an axon, and dendrites (Rogers, 2010, p. 11). The axon is a part of the nerve cell; although miniscule in real life diagrams the axon looks like a wire, and it varies in length and size. The axon transfers the electrical messages between the different neurons, receptors and effectors (Doidge, 2007, p. 53, Levitan & Kaczmarek, 2001, p. 10, Swan, 2008, p. 17). Dendrites are small limbs that emerge from the cell body of a neuron (Evans-Martin & Cooley, 2009, p. 14). Dendrites deliver the signals from the receptors, and the other neurons to the end of the axon through "the cell body, which sustains the life of the cell and contains its DNA" (Doidge, 2007, p. 53, Rogers, 2010, p. 11).

Although the neurons might seem connected to one another, there is actually a very small gap between any two neurons. The gap ranges between 10-20 nanometers. This gap is called a synapse, and it is in charge of transmitting and receiving chemical signals between neurons. The information is carried from one neuron to another through chemicals called neurotransmitters. Every neuron produces neurotransmitters at the presynaptic nerve (Evans-Martin & Cooley, 2009, p. 16). Neurotransmitters are chemicals that are created and released from the pre-synaptic terminals. Calcium ions are required for the release of the neurotransmitter from the pre-synapse, which affects post synaptic membranes (Evans-Martin & Cooley, 2009, p. 50). There are hundreds of neurotransmitters. The most commonly identified neurotransmitters are Acetylcholine, norepinephrine (nor-adrenalin), dopamine, GABA (gamma-aminobutyric acid), glutamate, serotonin, and endorphin (Boeree, 2009).

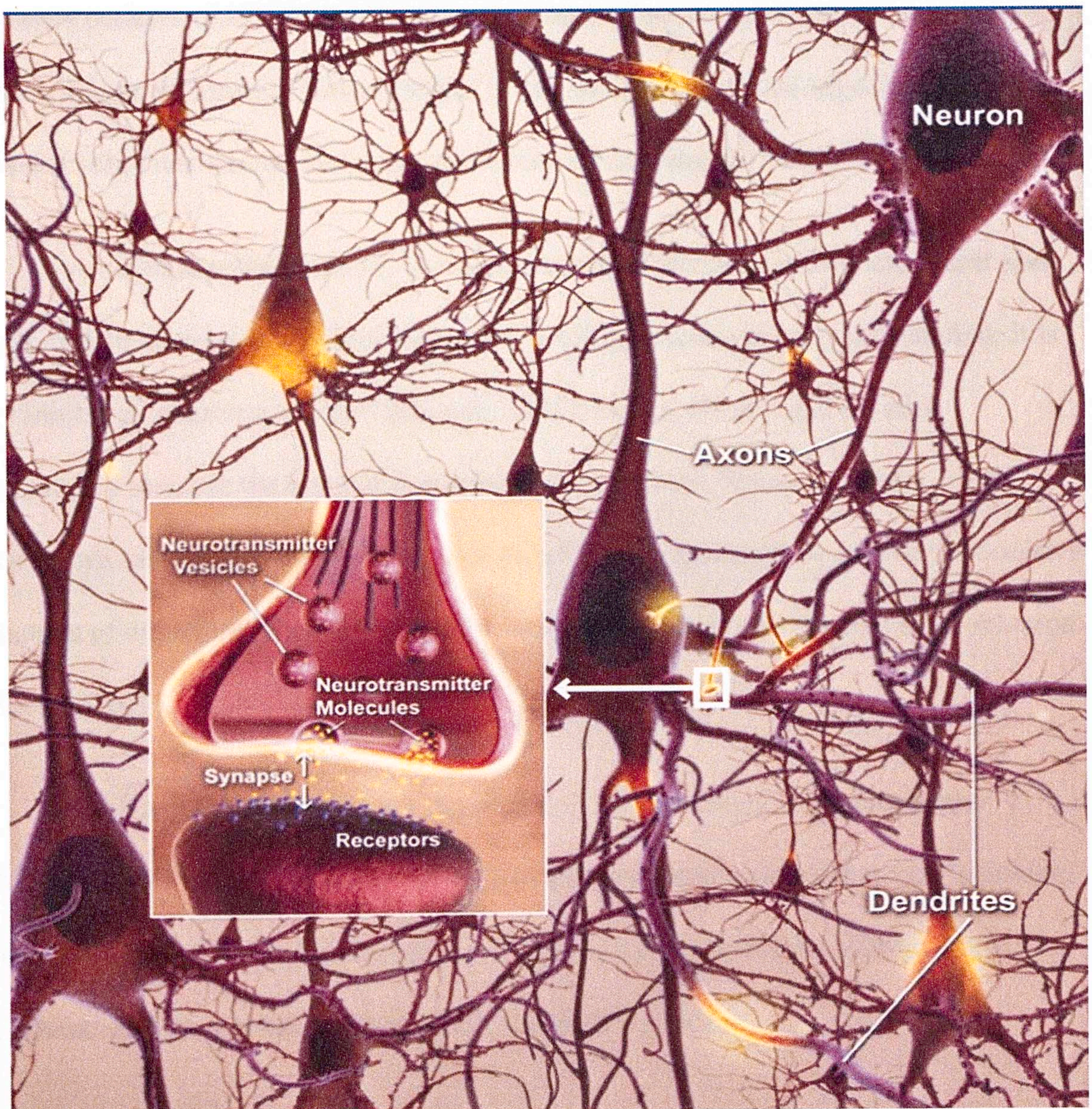

Figure 1: Neural Network (Aging, 2008, p. 14)

The first neurotransmitter discovered was acetylcholine. It plays a role in rapid eye movement (REM) as well as muscles functions. Acetylcholine has two receptors: nicotine and muscarinic (Boeree, 2009).

The nor-adrenaline has different functions such as forming and transporting memories from short term storage to long term storage (Boeree, 2009, Stauth & Khalsa, 1999). Also, the level of nor-adrenaline can affect sleeping patterns, sex drive, and a person's positive mood. Higher levels of nor-adrenaline will prevent a person from falling asleep; however, a lower level of it will weaken the sexual urge. In addition, a lower level of nor-adrenaline is the main cause of depression (Stauth & Khalsa, 1999).

Another neurotransmitter, dopamine, controls muscular movement, but it also stops certain neurons in receptor sites from sending or receiving any information. It is an "inhibitory neurotransmitter" (Boeree, 2009). Drugs, alcohol and nicotine temporarily increase the level of dopamine (Boeree, 2009, Stauth & Khalsa, 1999). It was shown that some mental illness such as schizophrenia could be related to excessive amounts of dopamine; thus, drugs that blocks dopamine are used to treat schizophrenia (Boeree, 2009).

GABA is considered a calming, relaxing and inhibitory neurotransmitter (Boeree, 2009, Stauth & Khalsa, 1999). It blocks neurotransmitters that lead to anxiety and nervousness. GABA can be enhanced with some drugs such as Valium while a lot of others, such as alcohol and barbiturates, work to reduce it.

Glutamate is very important to memory, learning and the function of the hippocampus (Boeree, 2009, World Health Organization, 2004, pp. 33-34); however, it can also be lethal. An excess of glutamate will kill neurons (Boeree, 2009). Glutamate has four receptors; NMDA (N-methyl-D-aspartate), AMPA (alpha-amino-3-hydroxy-5-methyl-4-isoxazole-4-propionic acid), kainate, and metabotropic glutamate receptors (Stauth & Khalsa, 1999).

Serotonin is another inhibitory neurotransmitter that is involved with emotions (Boeree, 2009). It regulates anger, aggression, and mood (Stauth & Khalsa, 1999). A low level of serotonin can lead to depression, anger, and suicide. A lower level of serotonin can also increase the appetite for foods high in carbohydrates. On top of emotional disorders, a low level of serotonin can also be tied to migraines.

Endorphin is an inhibitory neurotransmitter that has similar functions as morphine and heroin. It reduces pain and increases pleasure (Boeree, 2009, Stauth & Khalsa, 1999).

In other words, all of the neuron components (the axon, dendrites, and the cell body) have the same task of transporting the messages in electrical form (signals) through the dendrites; then, the signal travels from the dendrites to the end of the axon. After that, the electrical signal is transformed into a chemical signal at the presynaptic nerve before it crosses the synapse to the next neuron. Some neurons are only in charge of transmitting messages from outside or inside sources. These types of neurons are called receptors. The receptors collect different kinds of information from the surrounding environment, and send them to the brain using the same mechanism (Rogers, 2010, pp. 11-12).

The brain (shown in Figure 2) consists of three major parts: the brainstem, the cerebellum, and the cerebrum. The brainstem's main function is to control and command the muscles such as the heart and lungs. The brainstem contains several different parts, which are the midbrain, the pons, the medulla, the center, the thalamus, and the hypothalamus. The thalamus plays a very important role in modifying the level of attention and awareness. The second part of the brain is the cerebellum. It is what keeps the body balanced. It organizes nerves and the muscles' movement (Rogers, 2010, pp. 13-14).

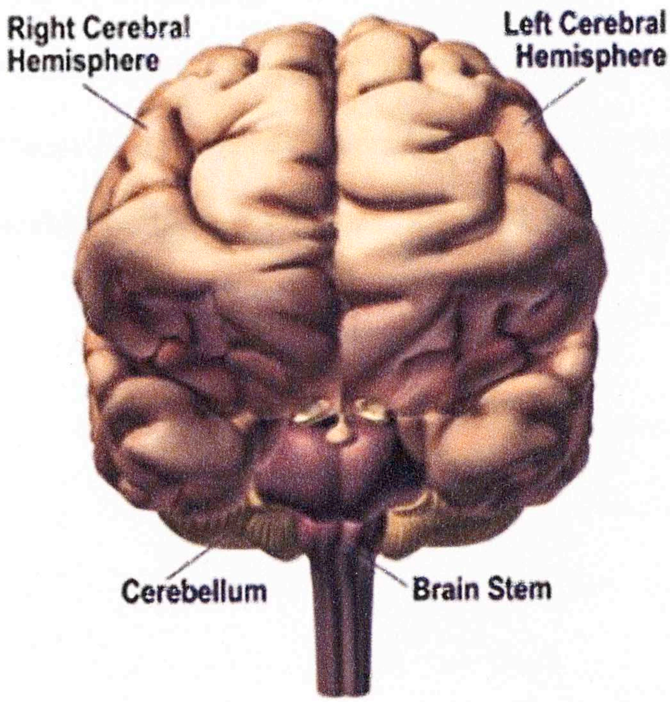

Figure 2: A Front View of the Brain (Aging, 2008, p. 10)

The cerebrum is the largest part of the brain. Its tissues are made out of the gray matter and the white matter. It can be seen that the cerebrum has two hemispheres: right and left. The different sides have different sizes, and each one of them is in charge of different functions, such as math or music. The thin, wrinkled outer layer of the cerebrum is called the cerebral cortex. It is made of gray matter. The wrinkles can be related to the level of intelligence; the more wrinkles the cortex has, the more intelligent the brain is. The cortex is divided into lobes, which are the frontal lobes, temporal lobes, occipital lobes, parietal lobes (Rogers, 2010, pp. 12-13)

The frontal lobes are located at the front of the skull (Figure 3); thus, the frontal lobes have a higher potential for injury (Rogers, 2010, p. 13). These lobes are responsible for higher mental functions such as memory, intelligence, judgment, and problem solving. The temporal lobes can be broken down to three gyri: the superior temporal gyrus, the middle temporal gyrus, and the inferior temporal gyrus. The temporal lobes play an important role in language, smell, and hearing while the occipital lobe is in charge of sight (Rice University, 2000, Rogers, 2010, p. 13). The partial lobe is responsible for the sense of touch (Rogers, 2010, p. 13).

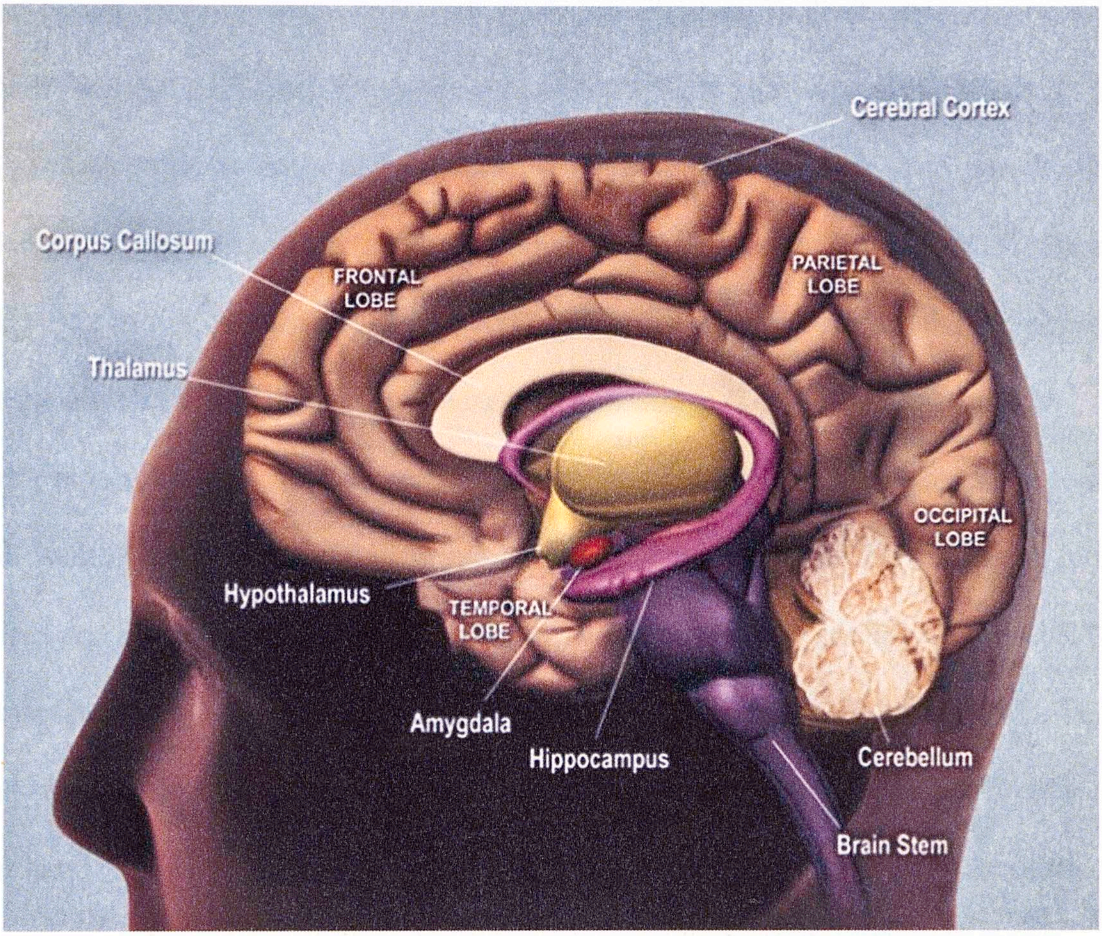

Figure 3: A Section View of the Brain (Aging, 2008, p. 10)

The other part of the nervous system, the PNS, consists of groups of nerves called ganglia. The ganglia contain the sensors that collect information (inputs) and send them to the CNS in order to give commands (output) based on the PNS information (University of Michigan Medical School, 2010).

The brain has billions of neurons and the individual neuron is able to connect with ten thousand other neurons. But if neurons weren't used or connected with other neurons, they will die (Arden, 2010, p. 10). This is how brain plasticity works; the connections between neurons are strengthened when new learning occurs or someone practices new skills. Otherwise, if a person neglects skills and stops learning the connections between neurons will weaken (Arden, 2010, p. 9). Plasticity also works through neuronal pathways. The brain system has several pathways. Brain plasticity is displayed when one specific pathway is closed or damaged. The brain will take another path even if it is longer to get the function done. By using the second path, the brain will find shorter routes over time (Doidge, 2007, p. 9). The pervious explanation emphasizes how the brain reorganizes itself and adapts to new things. The following example illustrates how brain plasticity function. People who are blind use their fingertips to read Braille text. Their brains are able to make the connections between the vision and touch cortices and process the text. In one experiment, Pascual-Leone and his team used TMS (Transcranial magnetic stimulation) on blind subjects to block their visual cortex. The result was that the subject couldn't feel the Braille text with their fingertips. On the other hand, non-blind subject were given TMS but they didn't lose their sense of touch at all because their vision and touch cortices are not wired together (Doidge, 2007, p.200).

Chapter 3: Discussion of Findings

The revolution of brain plasticity has changed the scientific community's perspective toward many physiological and psychological diseases. What was considered a hopeless case in the past may now be considered very possible to treat because of the brain's ability to adapt. It is critical for us to understand when and how brain plasticity works, what can enhance brain plasticity, and how we apply our understanding of plasticity in order to use it in more appropriate ways. The dogma was that the brain was fixed until scientists and researchers began to demonstrate its plasticity (Kajer, 2010).

Principle One: "Use it or lose it" (Arden, 2010, p. 9).

Arden (2010) says of the brain "use it or lose it". Brain plasticity is not exclusive to a certain age. Children's brains, though, are more plastic than adults and that explains the importance of learning in early age (Johansson, 2004). It is faster and easier to teach a child new hobbies or skills than an adult. Children also have higher potential to recover from brain injury compared to adults (Johnston, 2009). That's because adult's brains are matured but children's brains are still developing (Zillmer, Spiers, & Culbe, 2000, p. 273). In other words, brain plasticity declines through aging. However, plasticity does not fade away completely as people get older, so a person's brain can still adapt plasticity (Stiles, 2000). Adults and elders can benefit from brain plasticity too by keeping their brains fit (Dennis, 2000).

Environmental experiences can make changes in our brains (Baroncelli, Braschi, Spolidoro, Begenisic, Maffei, & Sale1, 2011). Also, plasticity is a feature of every brain. It is about how we enhance it and apply it in a positive manner. A person's ability to adapt to many situations in life is because of brain plasticity. Even if a person does not know about how it works; however, the speed of the progress depends on practicing and training. To achieve the maximum potential of plasticity, learning new things is required to help the brain build and strengthen new connections between neurons. Learning new skills means improving the physical and cognitive states of the body and brain after persistent training for weeks or months (Green & Bavelier, 2010).

Principle Two: "Neurons that fire together, wire together" (Baars & Gage, 2010, p. 83).

Baars & Gage (2010) state that "Neurons that fire together, wire together" (p. 83). That explains how learning new habits occur. When practicing a new habit for the first time, the connections between the neurons that are used are weak. By practicing, the connections between neurons are strengthened. Over time, a person will be able to do the new habit faster and more accurate. Later on, the brain will do it automatically. The more we get used to it, the higher chance of doing it later on; however, not to keep learning and training will deteriorate plasticity of the brain (Doidge, 2007, p. 58).

As mentioned earlier, as people age, their ability to learn and remember becomes more challenging. In order to protect themselves from this kind of decline, they should learn how to enhance their brain plasticity (LaRue & Hartman-Stein, 2011). There are three main resources to enhance plasticity: Physical, mental, and social activities (Polya, 2009, p. 23). These three activities contribute to an enriched environment that promotes healthy brain functions. Environmental enrichment means activities or experiences that cause mental arousal (Jain, 2011, p. 124). Experience can make direct changes in the neurons (Polya, 2009, p. 20). Physical exercises, such as aerobic exercise, can help older people improve their brain plasticity. It also increases the gray matter in the brain (Bavelier, Levi, Li, Dan, & Hensch, 2010). Physical exercise in general helps to improve the memory, slows the normal aging, and makes thinking and information processing faster (Polya, 2009, p. 29). Aerobic exercise improves the brain by causing structural and functional changes. The more exercise, the more changes a person can get and the less exercise, the less changes occur (LaRue & Hartman-Stein, 2011, p. 35). The physical exercise has to be challenging in order to be effective (Polya, 2009, p. 27). It also has to last for thirty minutes per session for 5 times a week; it can vary between aerobic, free weights, or cardio (Polya, 2009, p. 28). The benefits of the exercise will take some time like a few months to be seen, but practicing is needed to maintain these changes (Polya, 2009, p. 29).

A study conducted by Nichol and colleagues demonstrated how physical exercising positively causes changes in the brain. They use a mouse model of Alzheimer's disease. After 3 weeks of making older mice run, they noticed a reversion of cognitive decline which proved the benefits of physical exercising (LaRue & Hartman-Stein, 2011, p. 35). Another study conducted by Kramer et al (2005) focused on 124 older adults. They divided their sample into two groups, one to participate in aerobic exercises and the other one to participate in stretching and toning about an hour three times a week for six months. As a result, the aerobic group showed more improvement than the non-aerobic group on some cognitive tasks such as selective attention (Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005, LaRue & Hartman-Stein, 2011, p. 35).

It is essential to train the brain mentally or intellectually in order to improve brain plasticity. Brain training is about using cognitive exercises that help specific brain functions (Fernandez & Goldberg, 2009, p. 143). Mental activities have to be challenging and require concentration. Concentration or paying attention is an important factor in brain plasticity because we cannot change without it (Polya, 2009, p. 32). Learning a new language, learning to play a musical instrument, and doing Sudoku, and Crossword puzzles are some forms of intellectual activities that promote plasticity (Polya, 2009, p. 30). Learning a new language or skill strengthens neurons connections and contributes to form new ones; that makes the brain function better (Fernandez & Goldberg, 2009, p. 8). It takes about two months to get the results form brain training. Also, mental or intellectual exercise requires practicing at least five hours a week for most days (Polya, 2009, p. 31). Mental or intellectual activity has to be continuous to be effective and improve compliance (LaRue & Hartman-Stein, 2011, p. 40). There are some brain fitness programs and software which help people at different ages to develop their brains and enhance their plasticity. These kinds of programs are designed by neuroscientists and researchers (PositScience, 2012).

Physical and mental activities are more effective than social activities in brain growth (Polya, 2009, p. 38). However, social activities are important because they excite synapses and help form new synapses (Jain, 2011, p. 124). Social interactions reduce stress and provide new challenges which stimulate the brain (Polya, 2009, p. 38). Another factor that affects the plasticity through social activities is its impact on neurotransmitters. Cortical excitability is controlled by the balance of excitatory (glutamate) and inhibitory (GABA) neurotransmission. Greater excitement through several activities has been linked to greater plasticity, while social inhibition is associated with impaired plasticity (Johnston, 2009).

Chapter 4: Applying an Understanding of Brain Plasticity to Human Relations

Social workers, psychiatrists, teachers, counselors, and parents all deal with many psychological issues that require them to know what the most effective solution to deal with every issue. In this section of the thesis, brain plasticity principles will be discussed for use in counseling or other psychotherapies. In addition, an understanding of brain plasticity can add perspective to the treatment of a numbers of psychological disorders, such as obsessive compulsive disorder (OCD), attention deficit hyperactive disorder (ADHD), anxiety, and depression. Since the brain is plastic, the way we experience things around us, the way we think, and the way we feel have great impact in changing brain functions and structures (Polya, 2009, p. 20)

Cognitive behavioral therapy (CBT) is a great application of brain plasticity. Cognitive behavioral therapy makes changes in the brain through changing ways of thinking (Blakemore & Frith, 2005, p. 166). For example, patients with obsessive compulsive disorder (OCD) generally respond positively to cognitive and behavioral therapy. OCD is a disorder that is characterized by excessive thoughts. People with OCD do repetitive behavior in order to get relief (Heyman, 2009, p. 96). Jeffrey M. Schwartz has designed treatment based on brain plasticity that helps the patient have insight into his/her disorder (Doidge, 2007, p. 169). He shows his patients Positron Emission Tomography (PET) brain scans for normal people and compares them to OCD PET brain scans. This step provides insight and educates the OCD patients more about their disorder. After that, he works with them to identify OCD thoughts and focuses the attention on other pleasurable actions such as, reading or playing a musical instrument. In addition, it is recommend that the patient look at normal brain scans when he or she has an OCD attack to provide him/her with hope and courage (Doidge, 2007, pp. 170-171).It will take time for changes to occur in the brain but eventually it will occur. This approach worked with 80% of Schwartz's patients by combining with medications (Doidge, 2007, pp. 173-174). In fact, the brain changes that result from psychotherapy, such as talking therapy, is equal to the brain changes that result from psychotropic medications (Friedman, 2002).

CBT approved its efficiency in treating anxiety, anger, and depression in adolescents. Adolescence is a challenging phase of life and requires attention and care from caregivers, teachers, and counselors. In order to help adolescents learn how to react positively to their negative emotions and make this phase of their life productive, there is a program based on CBT and brain plasticity called "Mood management program" (Langelier & Connell, 2005). The Mood management program is designed to help adolescents build and form their skills (Langelier C. A., 2001, p. 1). This program teaches adolescents to identify what stimulates their negative thoughts, feelings, behaviors, and physical responses. Using a workbook, this program also provides them with strategies to cope better with their distress and issues. The workbook contains questions based on CBT, discussions, skills, and homework. Clients will learn how to challenge their faulty thoughts. It means they will change their brains by learning. Brain plasticity offers us the possibility to reshape and redesign our brains. Mood management program based on CBT is a very useful and creative way to help adolescents reshape their brains in a better way (Langelier & Connell, 2005).

Progressive muscle relaxation often is used with CBT as a way to manage anger and anxiety (Medow, 2010). Since stress interrupts some kinds of brain mental functions, it is recommended that relaxation techniques be used (Kolb & Whishaw, p.727). The amygdala, an almond-shaped tiny unit in the brain, is a very important element of the emotional system. The amygdala sets emotions such as anger and fear when it senses any environmental threat. Signals from the amygdala to the hypothalamus stimulate stress chemicals such as adrenaline and cortisol. Relaxation states provide calming experiences that normalize and alleviate the amygdala's activity. Neuroplasticity can be self-directed through muscle relaxation; while the other way is directing our focus and concentration. Self-directed neuroplasticity refers to the clients interactions with psychotherapy. Of course psychotherapists will supervise their clients and provide them with the instructions and guidance to support them. By practicing relaxation, the neural network will strengthen and relaxation statues will be dominant (Medow, 2010).

Some types of talking therapy such as cognitive behavioral therapy and interpersonal therapy are helping clients recover from depression. Such psychotherapy aims to assist the client to identify and understand the sources of the depression. It also helps the client to identify faulty thoughts that lead them to feel hopeless and depression. In addition, psychotherapy provides the depressed client with strategies and skills to fight depression (American Psychology Association, 2010).

Another form of psychotherapy is called bibliotherapy. Bibliotherapy is self-directed method where the client depends on reading books as a way to heal from psychological pain, depression, or distress. It also provides the reader or the client with problem solving skills and insight (White, p.85). Studies shows that adult clients who used bibliotherapy, showed improvement and they maintain their improvement (Floyd et al.,). Brain plasticity is displayed in bibliotherapy. The learning process of reading and developing new perspectives will stimulate the brain's neurons to make new connections and strengthen the old connections.

Since aging is associated with memory decline, elderly people can apply brain plasticity principles in their lives to improve their memory and cognitive functions. People who are 65 years of age or older have a chance of losing memory, logic, judgment, and the ability to reason because of dementia which is caused by Alzheimer's Disease (AD) (National Institute of Aging , 2002, Society of Neuroscience , 2012) Medication can help improve the symptoms and psychological comfort and support can lower the stress of care providers. Psychotherapeutic involvements can be favorable during the early stages of Alzheimer's. It gives insight about the disease for those who are caregivers. The most common defense mechanism is the denial of the affected people and their families (Burns, et al., 2005).

The brain functions begin to weaken before old age. It is believed that the loss of neurons and the change in the brain plasticity at the synapses is the main reason for the decay of the brain function. The changes that happen before AD can be detected by many harmful signs that lead to AD such as brain inflammation and amyloid beta deposits. These signs harm areas of the brain in charge of memory, learning, and cognition ability. The harming mechanism is impairing the synapses and leads to the death of the cell. It has been observed that there is neuron loss and changes in synapse functions in the hippocampus and neocortex, which are the brain's areas of language and memory, in AD patients. (Society of Neuroscience, 2012)

To enhance and maintain brain plasticity for AD patients, a rich and stimulating environment is required. Research shows that regular exercise, healthy diet, and cardiovascular exercise can improve neurogenesis, neuron communication, and hippocampus-related functions. It can also decrease the level of amyloid beta deposits. That can be done for older people, with or without AD. (Society of Neuroscience , 2012)

Physical activity does not only enhance cognitive functions, but also it protects middle aged individuals against dementia and neurodegenerative diseases like AD (Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005, Society of Neuroscience , 2012). It is related to a lower risk of cognitive impairment, AD, and dementia (Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005).

As we age, our vision starts to weaken and fade away. The reason is not just because our eyes start to fail, it is also because our vision processors in our brains start to weaken. Computer software is being developed to provide exercises that keep people's visual receptors up to its normal processing speed. There is also some software being developed that exercises fine motor control. Many people quit playing musical instruments, woodworking, knitting, and similar hobbies because they cannot control the fine movements of their fingers. Fine motor exercises will make a more defined hand map in the brain (Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005).

Mobility is another issue for older people. Similar to the visual and fine motor exercises, "gross motor control" is an exercise still under development that could help with this issue. Aging can cause the decrease of sensory feedback from the feet, which is one of the reasons for losing balance and difficulty in mobility over time. Exercises for gross motor control should decrease the loss of balance, the tendency to fall, and should help maintaining a more relaxed mobility (Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005, Merzenich, 2011).

Children's brains have greater plasticity than adults (Hoff, 2008, p. 59). That explains why learning a new language or skill is easier in children than adults (Doidge, 2007, p. 78). Also it explains why they have higher recovery rate from injuries than adults (Johnston, 2009). Jenkins, Merzenich, Miller, and Tallal designed a program based called Fast ForWord, in language and learning for impaired children. The program helps children improve their ability to hear by using seven interesting games (Doidge, 2007, p. 70). This program has helped children improve in reading, math, speaking, social communications, and science (Doidge, 2007, p. 74). Depending on the severity of the child's impairment, modifications can take more time. Children with severe impairment work from eight to twelve weeks but children with milder impairment would work on the program for fewer weeks (Doidge, 2007, p. 71). In a study conducted on 500 children at 35 locations (homes, hospitals, clinics) using Fast ForWord program, most of the children with language difficulties normalized after the program (Doidge, 2007, p. 72). The Fast ForWord program has also been effective even with some Autistic children. 25% to 70% of Autistic children have mental retardation (Dawson, Mottron, & Grensbacher, 2008). Since Autistic children have difficulties in languages and social communications, Fast ForWord helps them improve their social communications and language (Doidge, 2007, p. 75). There are also some teaching techniques based on brain research which help children improve. At the same, it will offer safe and interesting environment for children to learn and change positively. For example, teachers want children in the classroom to feel safe because a frightened child would not absorb the information or learn. So, they have to remove the frightening science class objects such as snakes or spiders. Another creative idea is to let the children practice a safety ritual. Such as, "We are a community of learners who take care of one another" which would help reduce fear and worries. For children with Autism or anxiety disorders, a teacher would make a symbol of a safe haven and encourage the children to put their names inside and then close it. A teacher must pay attention to the child's emotions because it is correlated to his/her memory. For example, some little steps could help the child feel safe and content such as singing with the classmates. It is also good to encourage the children and make them feel empowered or in control of their learning. For example, simplify activities into little steps, attaching a photo along with each step will help children learn and remind what to do, especially, with Autistic children, children with language impairment, and children with cognitive impairment (Schiller & Willis, 2008).

There is a school that specializes in learning difficulties for children and adults called Arrowsmith School in Toronto. Arrowsmith was founded by Barbra Arrowsmith Young and Joshua Cohen (Doidge, 2007, p. 36). Applicants to Arrowsmith School have to take up to 40 hours of assessments in order to know exactly what function in the brain needs improvement. Children with impaired learning study letters from foreign languages such as Urdu or Persian to improve their visual memories (Doidge, 2007, p. 36). Others memorize poems by listening to CDs to strengthen their auditory memories (Doidge, 2007, p. 39).

Chapter 5: Stories from the Literature

The section outlines success stories based on brain plasticity. These stories do not guarantee or try to convince the reader that brain plasticity would work for everyone or every case. There are many other factors (medical or social) that affect the ability of the brain to recover, which could be discussed in other research papers. These stories demonstrate some successes cases and give hope to other cases.

A Case of Alzheimer's

Tom Warren was diagnosed with Alzheimer's disease at the age of 50. Many doctors looked at the CAT (computerized Axial Tomography) scan of his brain and they diagnosed his condition as AD. In 1983, Tom started to experience AD symptoms such as memory loss and fatigue. Tom was having a hard time carrying good conversation. He started reading everything he could in order to find the roots of his AD and maybe find a possible solution. He would take notes about everything he thought was important. Sometimes he would read something that he could not remember five seconds later. His wife, who is a pharmacist, helped him understand his notes every day after she came home from work.

After reading about 50 books, he found that his life style contributed to his AD. He started to eat organic whole food, exercise regularly, and clean his environment of anything that could be toxic. He had all of his teeth fillings removed and avoided any kind of household chemical pollutant. In 1987, another CAT of his brain showed that his AD process had reversed. He returned to work after 11 years of being absent. Tom says "In one way or another, everything I learned pointed to: one, remove poisons from the body; two, learn how to live in your environment; three, balance body chemistry;

four, avoid junk food as if it were poison; and five, exercise. In time, the body will heal itself" (Goldberg, 2002, p. 528). The changes that Tom made in his life style to treat his AD are the same things were discussed earlier. With exercise and proper nutrition, he not only maintained his cognitive functions, he helped to reverse symptoms of AD and physical decline.

A Case of Learning Disabilities

As a child, Barbara Arrowsmith Young, the founder of Arrowsmith School, had times of brilliance that coincided with time of mental dullness. Her visual and auditory memory tested at the 99th percentile but she suffered from chronic learning disabilities (Bray, 2011, p. 183, Doidge, 2007, p. 27). She had difficulties pronouncing words, grammar, math concepts, logic, and spatial reasoning that help us know where to move in the space and know exactly where things are (mental map). She also had a problem with her vision because her vision is so narrow. She couldn't read more than a few letters at the same time, and she couldn't understand relationships between symbols (Doidge, 2007, pp. 27-29). "Her brother kept sulfuric acid for experiments in her old nose-drops bottle. Once when she decided to treat herself for sniffles, Barbara misread the new label they had written. Lying in bed with acid running into her sinuses, she was too ashamed to tell her mother of yet another mishap. Unable to understand cause and effect, she did odd things socially because she couldn't connect behavior with its consequences. In kindergarten she couldn't understand why, if her brothers were in the same school, she couldn't leave her class and visit them in their classroom whenever she wanted. She could memorize math procedures but couldn't understand math concepts" (Doidge, 2007, p. 29). When she was an undergraduate student, her teacher noticed that

Barbra had a great ability to understand nonverbal cues in the child observation laboratory. Then, she became a graduate student at the Ontario Institute for studies in education (OISE). She was struggling with reading a research paper twenty times with very little understanding (Doidge, 2007, p. 31). She started reading books many times in order to understand them. She re-read Reading Basic Problems of Neurolinguistics, especially a section about people who have trouble with logic, grammar, and reading the clock (Doidge, 2007, p. 32). In addition, when she was 28 year old and still in graduate school, she was reading a paper written by Mark Rosenzweig that inspired her to exercise herself mentally despite no guarantee of improvement. "Instead of practicing compensation, she exercised her most weakened function - relating a number of symbols to each other. One exercise involved reading hundreds of cards picturing clock faces showing different times…She shuffled the cards so she couldn't memorize the answers. She turned up a card, attempted to tell the time, checked the answer, and then moved on to the next card as fast as she could. When she couldn't get the time right, she'd spend hours with a real clock, turning the hands slowly, trying to understand why, at 2:45, the hour hand was three-quarters of the way toward the three" (Doidge, 2007, p. 36). At the end of her mental exercising journey that lasted for weeks of exhaustion, she succeeded in reading clocks faster than people normally do. She showed improvement in math, grammar, and logic and she communicated in a better way with other people because she understood exactly what they said. Her amazing success story led her to open Arrowsmith School to help children like her to improve and have normal lives (Doidge, 2007, p. 36).

A Case of Autism

Jason is three and half years old. He was diagnosed with Autism when he was two and half year old. He received speech therapy for six months without improvement and the child became more frustrated (Siri & Lyons, 2011, pp. 80-81). He could not communicate with words, so he started to act. For example, if he needed something visible, he would pull his mom or caregiver to the areas that included the thing he wanted. But, if he wanted something invisible, it would take many attempts to explain what he wanted and that made him frustrated. Jason did not show interest in verbal speech. He did not function well with gross motor movements. When the therapist introduced Jason to the computer, he did not pay full attention but he showed some interest (Siri & Lyons, 2011, p. 81). Jason started his training in Picture Exchange Communication System (PECS) and another program called Pre-Sign to learn about sign language. Jason also used a program that has series of animation used for special needs children along with a program to develop his language skills. After six months of training, Jason showed great improvement. After one year of training, Jason improved his communications skills. "He was verbalizing while using the PECS pictures and signs…His experience in computer usage proved to be a tremendous asset as he learned to use the touch screen communication device with ease. Through the device and computer - based intervention, he learned how to string words together to make short sentences. Ultimately, we were able to discontinue the voice output system because Jason developed the ability to speak on his own" (Siri & Lyons, 2011, p. 82). Jason continued to use computer-based intervention. Jason now is around 11 years old. He exchanges emails with friends, loves his iPod, wants to get a cell phone, and wants to pursue his education and go to college (Siri & Lyons, 2011, pp. 82-83).

A Case of Major Depression

Mr. L had suffered from depression for over 40 years. He had no music in his voice, and had relationship difficulties with women (Doidge, 2007, p. 215). He had problems with commitment. He was not loyal to his wife and they got divorced. He also, never had a sense of jealousy of others and never cried. His attitude toward his children was coming from a sense of duty, not joyful affection. Mr. L's mother had died when he was 26 months old. His father became the sole provider for him and seven siblings. When Mr. L was four years old, his father sent him to live with his aunt and her husband (Doidge, 2007, p. 216). Mr. L did not feel sad about what happened to him and did not remember anything before the age of four. Mr. L always had the same dream about him searching for something, probably a toy. Within three years, Mr. L was treated by psychoanalysis therapy and learned to link his dreams with his loss (Doidge, 2007, p. 217). By talking about his experiences, he gave himself a chance to realize what is going on with him. He began to understand his feelings. "In neuroplastic terms, activating and paying close attention to the link between everyday separation and his catastrophic response to them allowed him to unwire the connections and alter the pattern" (Doidge, 2007, p. 231). Now, he understands that his issue with commitment to women comes from his feeling that there is another woman who waits for him. He realizes that the woman in his dreams is his mother, and in order to be faithful to his mother, he can't commit to another woman. Mr. L has been more understanding of his symptoms of post-traumatic stress disorder that was caused by his mother's death and by separating him from his home and siblings at an early age. He expresses his anger in a better way, he has more control over himself than before, he has better relationship with his children, and he is facing his pain by using psychoanalysis therapy sessions (Doidge, 2007, p. 234). Mr. L finally has normal sadness, feeling occasionally without being depressed. In addition, he falls in love and has commitment to his lover. He has the sense of normal jealousy. He feels different; he feels better (Doidge, 2007, p. 237).

Conclusion

In order to help patients recover, they have to be motivated (Doidge, 2007, p. 24) Educating our clients about brain plasticity and making them aware of it, will give them the hope, insight, courage, and strength to face their problems. It will increase their determination for recovery. In addition, the education about brain plasticity will direct clients' attention toward learning (Medow, 2010), whether that learning is emotional, physical, kinesthetic, or intellectual. Humans are powerful creatures. They can alter their brain function by consciously directing their attention. Psychotherapy based on brain plasticity principles aims to reduce the level of stress in clients, make them more positive, enable them to have control over their problems, provide them with techniques to cope better with their issues, and help them to have healthier lives (Medow, 2010).

References

Aging, N. I. (2008). *Alzheimer's Disease: Unraveling the Mystery.* Silver Spring, MD: U.S. Department of Health and Human Services.

American Psychology Association. (2010, July). *Understanding depression and effective treatment*. Retrieved 2 2012, from American Psychology Association: http://www.apa.org/helpcenter/understanding-depression.aspx

Arden, J. (2010). *Rewire Your Brain: Think Your Way to a Better Life.* Hoboken, New Jersey : John Wiley & Sons.

Baars, B. J., & Gage, N. M. (2010). *Cognition, brain, and consciousness: introduction to cognitive neuroscience* (2 ed.). Salt Lake City , UT: Academic Press.

Baroncelli, L., Braschi, C., Spolidoro, M., Begenisic, T., Maffei, L., & Sale1, A. (2011). *Brain Plasticity and Disease: AMatter of Inhibition.* Hindawi Publishing Corporation.

Bavelier, D., Levi, D. M., Li, R. W., Dan, Y., & Hensch, T. K. (2010). Removing Brakes on Adult Brain Plasticity: From Molecular to Behavioral Interventions. *The Journal of Neuroscience , 30* (45), 14964 –14971.

Blakemore, S.-J., & Frith, U. (2005). *The learning brain: lessons for education* (1 ed.). Malden, MA, USA: Blackwell.

Boeree, D. C. (2009). *General Psychology*. Retrieved 2 1, 2012, from Neurotransmitters: http://webspace.ship.edu/cgboer/genpsyneurotransmitters.html

Bray, M. A. (2011). *The Oxford handbook of school psychology* (1 ed.). New York , NY, USA: Oxford University Press, USA.

Burns, A., Guthrie, E., Marino-Fran, F., Busby, C., Morris, J., Russel, E., et al. (2005). Brief psychotherapy in Alzheimer's disease: Randomised controlled trial. *British Journal of Psychiatry , 187*, 143-147.

Cramer, S. C., Sur, M., Dobkin, B. H., O'Brien, C., Sanger, T. D., Trojanowski, J. Q., et al. (2011). Harnessing neuroplasticity for clinical applications. *Journal of Neurology , 134* (6), 1591-1609.

Curtis, A., & O'Hagan, M. (2008). *Care and Education in Early Childhood: A Student's Guide to Theory and Practice* (2 ed.). New York, NY: Routledge.

Dawson, M., Mottron, L., & Grensbacher, M. A. (2008). Learning in Autism. In J. H. Byrne (Ed.), *Learning and Memory: A Comprehensive Reference Volume 2* (Vol. 2, pp. 759-772). Salt Lake City, UT, USA: Elsevier.

Dennis, M. (2000). Developmental Plasticity in Children: The Role of Biological Risk, Development, Time, and Reserve. *Journal of Communication Disorders , 33*, 321–332.

Retrieved Jan 24, 2012, from Columbia university medical center: http://www.columbianeurosurgery.org/specialties/peripheral-nerve/

Doidge, N. (2007). *The Brain that Changes itself.* New York: the Penguin Group.

Evans-Martin, F. F., & Cooley, D. A. (2009). *The nervous system.* Langhorne, PA: Chelsea House Publications .

Fernandez, A., & Goldberg, E. (2009). *The Sharp Brains Guide to Brain Fitness.* San Francisco, CA: Sharpbrains, Inc.

Friedman, R. A. (2002, August 27). Like Drugs, Talk Therapy Can Change Brain Chemistry. *The New York Times* .

Goldberg, B. (2002). *Alternative medicine: the definitive guide* (2 ed.). New York: Crown Publishing Group.

Green, C. S., & Bavelier, D. (2010). Exercising Your Brain: A Review of Human Brain Plasticity and Training-Induced Learning. *Psychology and Aging , 23* (4), 692–701.

Heyman, G. M. (2009). *Addiction: a disorder of choice.* Cambridge, MA, USA: Harvard University Press.

Hocking, D., & Horton, J. (1997). Timing of the critical period for plasticity of ocular dominance columns in macaque striate cortex. *The Journal of Neuroscience , 17* (10), 3684–3709.

Hoff, E. (2008). *Language development* (4 ed.). Belmont, CA, USA: Wadsworth.

Hubel, D., & Wiesel, T. (1970). The period of susceptibility to the physiological effects of unilateral eye closure in kittens. *Journal of Psychology , 206*, 419-436.

Jain, K. K. (2011). *The Handbook of Neuroprotection.* New York, NY: Springer.

Johansson, B. (2004). Brain plasticity in health and diseases. *Keio Jounal of Medicine , 53* (4), 231-246.

Johnston, M. V. (2009). Plasticity in The Developing Brain: Implications for Rehabilitation. *Journal on Developmental Disabilities* .

Kajer, E. A. (2010). *The power of change: How mind and body therapies can be used effectively in counseling.* University of Tennessee. (1388).

Kolb, B., Gibb, R., & Robinson, T. (2003). Brain plasticity and behavior. *Current Directions in Psychological Science , 12* (1), 1-5.

Kramer, A. F., Colcombe, S. J., McAuley, E., Scalf, P. E., & Erickson, K. I. (2005). Fitness, aging and neurocognitive function. *Neurobiology of Aging , 26S*, S124–S127.

Langelier, C. A. (2001). *Mood Management: A Cognitive-Behavioral Skills-Building Program for Adolescents; Skills Workbook.* Thousand Oaks, CA, USA: Sage Publications, Inc.

Langelier, C. A., & Connell, J. D. (2005). Emotions and learning: where brain based research and cognitive-behavioral counseling strategies meet the road. *Rivier College Online Academic Journal , 1* (1), 1-13.

LaRue, A., & Hartman-Stein, P. E. (2011). *Enhancing Cognitive Fitness in Adults: A Guide to the Use and Development of Community-Based Programs* (1st ed.). New York City, NY: Springer.

Levitan, I. B., & Kaczmarek, L. K. (2001). *The neuron: cell and molecular biology* (3rd Edition ed.). New York: Oxford University Press.

Marshall, J. F. (1984). Brain function: Neural adaptations and recovery from injury. *Annual review of psychology , 35*, 227-308.

Medow, H. (2010). *Neuroplasticity: The Biology of Psychotherapy.* Retrieved 10 13, 2011, from Heisel and Associates: http://www.heiselandassoc.com/Mydocs/Medow%20Neuroplasticity.pdf

Mercado III, E. (2008). Neural and Cognitive Plasticity: From Maps to Minds. *Psychological Bulletin , 134* (1), 109-137.

Merzenich, M. (2011, July 13). *Visual training to retain driving competence and your independence!* Retrieved Feb 2012, from On the Brain with Dr. Mike Merzenich, Ph.D.: http://merzenich.positscience.com/?cat=4

Morgan, S. (1995). Localization of brain function: The legacy of Franz Joseph Gall (1758-1828). *Annual review of neuroscience , 18*, 359-383.

Murphy, T. H., & Corbett, D. (2009). Plasticity during stroke recovery: from synapse to behaviour. *Nature Reviews Neuroscience , 10*, 861–872.

National Institute of Aging . (2002). *Alzheimer's Disease: Unraveling the Mystery.* Bethesda, Maryland: National Institute of Health .

Polya, A. J. (2009). *Brain Fitness: Breakthrough Training for Those Who Mind.* Bloomington, IN: Xlibris, Corp.

Porto, P. R., Oliveira, L., Mari, J., Volchan, E., Figueira, I., & Ventura, P. (2009). Does Cognitive Behavioral Therapy Change the Brain? A Systematic Review of Neuroimaging in Anxiety Disorders. *The Journal of Neuropsychiatry and Clinical Neurosciences , 21*, 114-125.

PositScience. (2012). *Brain Training Software*. Retrieved from Brain Training Software: http://www.positscience.com

Rice University. (2000, June 26). *Temporal Lobe*. Retrieved 1 30, 2012, from Langbrain: http://www.ruf.rice.edu/~lngbrain/cglidden/temporal.html

Rogers, K. (2010). *The brain and the nervous system.* Rosen education service.

Sabbatini, R. (2002, 06 11). *Phrenology: the History of Brain Localization*. Retrieved 10 13, 2011, from Brain and Mind: http://lecerveau.mcgill.ca/flash/capsules/articles_pdf/phrenology.pdf

Sabatini, ,. U., Toni, ,. D., Pantano, ,. P., Brughitta, ,. G., Padovani, ,. A., Bozzao, ,. L., et al. (1994). Motor recovery after early brain damage. A case of brain plasticity. *Stroke: Journal of the American Heart Association , 25* (2), 514-517.

Schaffer, H. R. (2007). *Key concepts in developmental psychology.* Thousand Oaks, CA: Sage Publications Ltd.

Scheff, S. (2003). Reactive synaptogenesis in aging and alzheimer's disease: Lessons learned in the Cotman laboratory . *Journal of Neurochemical Research , 28*, 1625-1630.

Schiller, P., & Willis, C. A. (2008). Using Brain-Based Teaching Strategies to Create Supportive Early Childhood Environments That Address Learning Standards. *National Association for the Education of Young Children* , 1-6.

Siri, K., & Lyons, T. (2011). *Cutting - Edge Therapies for Autism.* New York: Skyhorse Publishing.

Society of Neuroscience . (2012). *Brain Plasticity and Alzheimer's Disease*. Retrieved Feb 2012, from Society of Neuroscience : http://www.sfn.org/index.aspx?pagename=publications_rd_alzheimers

Stauth, C., & Khalsa, D. S. (1999). *Brain Longevity: The Breakthrough Medical Program that Improves Your Mind and Memory.* New York : Grand Central Publishing.

Steinberg, L., Vandell, D. L., & Bornstein, M. H. (2010). *Development: Infancy Through Adolescence* (1 ed.). Wadsworth Publishing.

Stiles, J. (2000). Neural Plasticity and Cognitive Development. *Developmental Neuropsychology , 18* (2), 237–272.

Stookey, B. (1954). A note on the early history of cerebral localization. *Acad med , 30* (7), 559-578.

Swan, J. (2008, April 7). *The nervous system.* Retrieved Jan 24, 2012, from Class videos: http://classvideos.net/anatomy/pdf/3708091011-pdf.pdf

Tizard, B. (1959). Theories of brain localization from Flourens to Lashley. *Med History , 3* (2), 132-145.

University of Michigan Medical School . (2010). *Peripheral Nervous System.* Retrieved 2 1, 2012, from University of Michigan Medical School : http://histology.med.umich.edu/medical/peripheral-nervous-system

World Health Organization. (2004). *Neuroscience of psychoactive substance and use dependance.* Geneva: Publications of the World Health Organization.

Zillmer, E. A., Spiers, M. V., & Culbe, W. C. (2000). *Principles of Neuropsychology.* Florence, KY: Wadsworth Pub Co.