NEUROPLASTICITY

BRAIN TRAINING UNLEASHED

CLARENCE T. RIVERS

Neuroplasticity

Master the Art of Brain Plasticity!

Clarence T. Rivers

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INTRODUCTION

I want to thank you and congratulate you for downloading the book, *Neuroplasticity: Master the Art of Brain Plasticity!*

This book will open your eyes to the remarkable truth about the awesome power of our brain as it continues to regenerate and learn, re-learn, and unlearn things around us from birth to death. It debunks the idea that the adult brain is a rigidly structured body organ that develops into full maturity only during the early stages of our lives.

This book reveals the fact that the brain can be trained to develop new pathways that will augment and strengthen knowledge action at any stage of our life span. It will also help you appreciate better the brain's ability to recover from injury or disease and reorganize itself to attain optimal performance despite damage or disease which tends to disrupt its functionalities.

Most important of all, the book reveals new avenues you can explore in possibly re-inventing ourselves as well as discover new approaches to treating addiction, autism, and helping stroke patients to recover.

Thanks again, I hope you enjoy it!

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CHAPTER 1

The Amazing Capacity of the Human Brain

Conventional wisdom taught us that we were born already with neurons we will possibly need for the rest of our lives. (*Neurons are the brain cells that processes and relays information to each other via electrical impulses or chemical signals which essentially triggers corresponding responses by our body*.)

We were also made to believe that the brain circuitry connecting these neurons together which allows our body to behave or respond to all internal and external stimuli have already been set rigidly in place during the early stages of our lives - such that it would therefore be difficult for us to learn new things and acquire new skills during the twilight of our lives. Conventional knowledge mistakenly made us believe that the brain becomes rigid and static during adult stage with no new brain cells (neurons) being generated and with the old cells dying as we age.

This knowledge, however, is now considered as 'old-school' as mounting evidence have cropped up proving that neurogenesis (*the brain process that generates neurons from progenitor cells and neural stems*) in human beings actually occurs not only during childhood but throughout one's lifetime (*i.e. from inception till death*). This can only mean one thing - no is going to be too old to learn new tricks or develop new habits because newly generated neurons will always be there to make it happen.

What is becoming more interesting and beneficial though, particularly to parents and educators are the numerous related scientific studies showing that existing neurons as well as those that have just been newly generated can undergo changes in structure as well as functionality in response to how individuals consciously interact with his surroundings. Again, this can only mean one thing – we can re-invent our brains through the choices we make on how we want to respond to the things we interact with.

Another significant breakthrough which recent neural studies have revealed is the fact that the brain not only has the capacity to regenerate but can also reorganize and repair itself to cope with brain injury or disease. The human brain tries to keep our body organs functioning normally and at optimal levels such that when certain brain cells are impaired due to brain injury or disease, it sources out ways to maintain normalcy by rerouting the tasks used to be performed by the damaged brain cells to other undamaged cells of the brain.

The brain's amazing ability to perpetually regenerate, its capacity to learn, unlearn, and re-learn things according to every individual's choice response, its capability to reorganize and restructure its neural networks in response to learning and experience,

all fall under a not-so-new category of brain science called neuroplasticity. Because 0f the wide ranging implications of this fast emerging branch of science to our quality of life, neuroplasticity has become the focus of the most fascinating research studies today.

What is Neuroplasticity?

Neuroplasticity is the term used to describe the intrinsic property of the brain to re-organize its neurons and modify the connections of its neural networks in response to various factors like brain development, new data that comes its way, stimulation of the sensory organs, damage or disease to some of the neurons. It is also known by such names as brain plasticity and neural plasticity.

The term neuroplasticity was first coined in 1948 by Dr. Jerry Konorski, a neurophysiologist of Polish Descent. (*Perhaps, the choice of the word 'plasticity' is in reference to the unique property of malleable plastic – it can be moulded into any shape or size you want when heated.*) Back then, the idea of brain plasticity was still nothing more than a concept which majority in the medical profession treated with their tongues in their cheeks. It was but a mere theory bereft of extensive studies and related research work to back it up.

The plasticity of the brain is not a new concept though. As early as 1793, Michele Vicenzo Malacarne, an Italian anatomist, through an experiment he conducted using laboratory animals, discovered that the brain is not really a rigid, unchanging structure as most people believed. He dissected the brains of a pair of these animals which he had extensively trained previously and compared them to the brains of a pair of untrained animals. He found out that the cerebellums of the two trained animals are significantly larger than those of the untrained pair showing that the brain grows with training. Unfortunately, nobody saw the significance of his discovery then and his findings was soon relegated to the dustbin of history.

Almost a century after that, in 1890 to be exact, a Dr. William James once again floated the same idea that neither the brain nor its functions are fixed during our adult life through his book Principles of Psychology which was published in the same year. But once again, the medical profession simply shrugged off the idea.

It took another 33 years before another study giving proof of the existence of brain plasticity came up. It was in 1923 when Karl Lashley experimented with monkeys to show that the brain has the capacity to create new neural pathways after the old pathways were blocked or severed. But once again, majority of the brain scientists in his time weren't warm to the idea and didn't realize the wide ranging implication of his experiment.

It was not until the mid 1960's when the community of neuroscientists from all over the world started paying heed to the idea of brain plasticity. The flurry of evidences culled from numerous experiments and research works by other renowned brain

scientists (like Paul Bach-y-Rita and Michael Merzenich) started flooding the news wires and medical journals with incontrovertible proof that neuroplasticity does exist.

Today, Neuroplasticity has ceased to be a mere theory. It is now an undeniable fact of life the understanding of which opens vast avenues for improving our quality of life. It is no wonder that hordes of brain scientists and researchers today burn out the oil lamps searching for other wonderful ways to use this new found knowledge. They have all been bitten by the neuroplasticity bug. It is no wonder too that even parents and educators are voraciously lapping up whatever neuroplasticity materials they can lay their hands on. In the first place, they owe it to the children to provide them the best brains possible to secure their future.

Even scientists looking to develop a brain-computer interface technology to be used by people with impaired senses have found great value in the advances made on neuroplasticity - using their knowledge of the emerging science as the foundation of their research. The burgeoning knowledge about neuroplasticity is also helping medical practitioners. Their appreciation and changing perception about neuroplasticity gave them more options to explore new ways to handle the brain damage caused by stroke and manage other clinical cases like chronic pain, emotional disorders, psychopathic cases, etc. Without a doubt, any brain research based on neuropathy will lead to better treatment and management of clinical cases involving the brain.

CHAPTER 2

No Longer a Concept, but a Fact of Life

Neuroplasticity is the inherent ability of the brain to change and reorganize itself in response to learning and experience. When a thought strikes you, the brain creates a synapse (*the structure that allows the neurons to transfer chemical or electrical signals to another neuron*) to represent this thought. When you learn new things, new brain cells (neurons) are created to store this knowledge as memory. While you are asleep, the brain builds new bridges (*new synapses*) and prune old bridges (*old synapses*). These are essentially the manifestations of neuroplasticity at work.

The brain is constantly engaged with creating new connections and pruning existing ones. It is constantly changing functionality and shape when new connections are formed between neurons as a reaction to stimulation triggered by learning or experience. It is perpetually pre-occupied with the continuing process of remodelling existing synapses - altering, strengthening, stabilizing, and pruning them to attain and maintain optimal functionality and ensure appropriate response to each and every stimulus at all times. It can even change the functionality of certain neurons if the situation calls for it -or re-route functions by creating new neural pathways when there is injury to some brain cells. These are all the neuroplasticity processes which keep the brain busy all the time – even while we are asleep.

Amazingly, the brain is able to manage multiple neuroplasticity processes like these in several locations all at the same time. If you are wondering how on earth the brain is able to coordinate such processes (*which involve billions of neurons linked to each other via trillions of synapses*) all at the same time, the answer lies in the widespread multi sensory integration of the neurons in the human brain allowing them to function as a single network in performing a task as a response to a stimuli or anything that may have influenced the brain into action. The stimuli are the triggers which make the brain snap the neurons into action. These triggers can be anything from a simple word, a memory, a thought, an experience, learning, the environment, and everything external or internal that may influence the brain.

To have a better understanding of how these triggers induce changes in the neurons' behaviour, we need to go down to the level of the neurons and see what goes on there. What we will see is a tiny neuron that can support a gigantic axon *(the protoplasmic projection from a cellular body that connects to another neuron and acts as the cell's signal transmitter).* The axon can extend from the spinal cord to the foot and connect up to 100,000 dendrites (*a similar protoplasmic projection which acts as the signal receiver*) to form synapses.

Neurons have a voracious appetite for information and are constantly searching for

them. In the presence of fresh information or triggers, these neurons may start creating connections to other neurons aggressively. Or, they may instead just strengthen their existing bonds with other neurons by creating more synapses to their axons. (*This is what usually happens when we get older since by that time we have enough of the important neural connections we need already in place*.) Besides generating neurons and creating synapses, the brain also trims down its neural connections by cutting down synapses that are rarely used or have not been used at all. The whole process is known as synaptic pruning – a continuing brain activity where synaptic connections are removed or re-created depending on their use.

Synaptic pruning is a necessary process meant to make sure that the brain does not waste precious resources on neural networks that are of little or no use at all. It is also the same process used to remove faulty or damaged neural connections. Remember that we were born with more neurons and synapses than we will ever need during our adult life. Pruning rarely used synaptic connections is the brain's way of maintaining its efficiency.

Unfortunately, there are times when seldom used but important skills are also pruned. This may be the reason behind the bouts of memory failures or forgetfulness we often encounter as we age. It is also the reason why the brain is sometimes described as a 'use it or lose it organ. The memory lapses may result from the diminishing performance of neural connections due to the degrading of rarely used synapses (synaptic pruning).

In essence, our capacity to recall memory, remember skills, or learn new knowledge depends a lot on synaptic pruning. We tend to excel on tasks where there are more existing neural connections especially if these connections are strong.

We can use our knowledge of neuroplasticity to excel on performing a particular task. By being mindful of the task we undertake and by constantly practicing the said task, we can induce the neurons to create more synapses and strengthen the neural connections specific to the task. Remember, thought alone triggers the brain into action. The numerous and strengthened neural connections will make it easier for us to perform the task and even excel in doing it. No less than Aristotle pointed this out centuries ago when he said, "*We are what we repeatedly do. Excellence, then, is not an act, but a habit*."

In its most fundamental form, neuroplasticity can thus be described as an on-going process of creating and pruning synapses (*neural connections*). It is a process where neural pathways that are repeatedly used are fortified while the less treaded ones are ultimately pruned off. This is where the saying '*use it or lose it*' finds great meaning.

CHAPTER 3

Early Brain Growth

The human brain goes through a period of amazingly rapid growth while still *in utero* – barely 18 days after fertilization. At this point, the brain begins to grow at an unbelievable rate of 250K to 1 million brain cells per minute. The brain process by which neurons are generated from the neural stem and progenitor cells is called neurogenesis. It is this process which is responsible for populating the brain with neurons.

Neurogenesis literally means the *birth of the neurons.* The process itself hits the peak of 'giving birth to neurons' during the prenatal stage (*while the fetus is still the womb*). While it may be quite difficult to determine exactly which of the regions of the brain play host to neurogenesis, numerous studies are presently being conducted to find ways on how to achieve this. The difficulty stems from the fact that it is almost impossible to see live brain cells in the human brain with existing technology.

For now, we can be satisfied with existing data culled from the most recent studies. These studies have provided incontrovertible proof that neurogenesis occurs in at least 2 (*possibly 4*) regions of the brain - as gleaned from the presence of new neurons in these regions.

The first region where new brain cells were always detected is the sub-granular zone of the hippocampus. This is the part of the brain that has been linked to memory, learning, and spatial navigation. It is located under the cerebral cortex in the medial temporal lobe.

The second region of the brain where new brain cells were confirmed to have actually been generated is the Sub Ventricular Zone located along the lining of the lateral ventricles. It has been observed that newly generated neurons migrate from this region of the brain to the olfactory bulb passing through the rostral migratory stream. (*The olfactory bulb is linked to our sense of smell.*) However, despite this observation, researchers are still not discounting the possibility that the olfactory bulb may also be generating some of the new neurons found in that region.

The hypothalamus, the region of the brain responsible for metabolism also yielded newly generated neurons leading researchers to theorize that fat cells may have stimulated the generation of more neurons to help coordinate metabolism. This however will still have to be confirmed by on-going research. If confirmed, it will have profound implications to our health.

Postnatal Development

After birth, the post natal development and maturity of the young brain becomes largely dependent on the stimulation it gets from first hand experiences of the child with his surroundings. These early experiences greatly impact the brain architecture and determine its capabilities in the near future.

It is during this early stage of life that the millions of neurons that were previously generated *in utero* start to form linkages with each other and develop neural pathways which will make learning rather easy for the child throughout the post natal period. If you ever wonder why a child learns fast, it is because he has neurons and synapses all over the place.

We also know that genetics and possibly some prenatal influences may have already laid down the groundwork for the development of the young brain. However, it is still the child's first hand experiences with his surroundings which will truly shape the full potentials (*or, in some cases weaknesses*) of the growing brain in the end.

During these early stages of brain development, the neural pathways will be in a constant state of change – continually restructuring and re-routing according to the quality, the quantity, and the timing of experiences the child encounters as he grows up. Every new experience gained forms a new dendrite which connects the neuron to specific sites of the brain. A new neural pathway is also created representing each of the newly acquired experience. It may interest you to know that a single dendrite can connect the neuron to approximately 200,000 other neurons and become part of several existing neural networks.

Cellular Composition of the Brain

There are more than 100 billion neurons in our brain with 5 times that number of neuroglial cells. Together, these two comprise what is known as the gray matter of the brain.

The neurons carry out the work of processing the input and output of information as triggered by our experiences and sending out signals to initiate potential action by the corresponding body organs. Not all of the neurons are tied up to this task though. About 20% of them are dedicated to policing every neural response to a stimulus– that is, they are tasked with suppressing an inappropriate response to a stimuli - if and when it occurs.

The neuroglial cells on the other hand, bring the much needed nutrients and oxygen to the neurons to keep them healthy and functioning efficiently. They also take out the cellular waste from the neurons and are therefore an important part of the brain ecosystem. They outnumber the neurons 5 to 1.

Contrary to conventional knowledge, the brain continues to generate neurons even during our adult age. The implication of this is profound. It means with new neurons

being generated throughout our lifetime, we will never lose the capacity to acquire new knowledge and learn new skills no matter how old we get.

CHAPTER 4

Neuroplasticity and Intelligence

For a long time, majority of us clung to the wrong notions about the human brain. This is because much of our knowledge about the brain is culled from conventional wisdom that is primarily based on the outdated scientific understandings of the 1950's. As a result, we held on to a heap of faulty ideas for a long time - like 'our ability to learn or acquire new skills is bound to decline as we age'; 'our memory will progressively falter as we grow older'; 'the number of our brain cells decreases every year'; 'our IQ is set by the age of five and will remain constant at this level for the rest of our lives'.

Well, what used to be myth (*neuroplasticity*) is now the universal truth and what used to be the universal truth (*all the faulty ideas above*) is now myth. It has been proven over and over again by numerous contemporary studies that human intelligence is not fixed or static – it can be increased; that even the personality traits we have exhibited since childhood can be changed; that we can inject new life to an aging brain; that damaged or impaired brains can regain full functionality.

That's right. Neuroplasticity, the emerging science that has caught everyone's undivided attention lately, is making all these happen. The adage '*you can never teach an old dog new tricks*' has become totally irrelevant because of this. Just like in the old times when people thought the earth was the center of the universe until Coppernicus proved this belief is wrong and changed everybody's perspective, the cumulative studies about the plasticity of the brain is drastically also changing our views about the brain and so we are starting to realize the awesome power of the brain to effect changes.

The more recent brain studies have provided proof that intelligence is not fixed. Lifelong personality traits can be changed. Learning disorders can be cured. Aging brains can be rejuvenated. Damaged brains can recruit other regions to regain full functioning. The best part is, given time and effort plus a little push from supplements, we can increase our intelligence profoundly.

Neuroplasticity has opened vast avenues of opportunities to reshape our brains and re-invent ourselves. The potential it is offering us to improve the quality of our lives is seemingly limitless bounded only by our own mindset and our willingness to take up the challenge of improving our quality of life.

The million dollar question now is how do we make use of our knowledge of neuroplasticity to increase our intelligence? To answer this question we need to take stock of what we know about our brain and what we've learned about its neuroplasticity.

So far, we know that our brain power which includes our memory and mental abilities has the capacity to improve throughout our lifetime. We also know that mental events such as thoughts can influence changes in the function and the neural structure of the brain. We know for a fact that there are a lot of people with average intelligence who have sharpened their cognitive skills, raised their IQ, and improved their memory tremendously. We know that the brain will never stop generating new brain cells till death.

We also know that the brain re-wires itself by creating new neural networks for the things we do repeatedly. We know that if we are mindful of the task at hand and focus on it, we are actually inducing our brains to strengthen the neural network for it which will sustain us until we've perfected the skill. We've also learned that the brain is a 'use it or lose it' body organ and so we have to keep using the knowledge and skills we want to retain otherwise they will be pruned.

These are the things we know about the brain and neuroplasticity so far. They may seem few but they are more than enough to help us map a strategy on how to increase our intelligence. To get started, we must remember how the brain works, e.g. whenever we engage a mental event like thinking, learning, or remembering, the brain snaps a group of neurons into action to start working with each other to accomplish the task. If the task is too difficult to perform or the group of neurons initially tapped for the task is unfamiliar with it, the brain will draw in the whole neighbourhood to help out with the task.

Here are some of the things you can get started with to improve your intelligence:

Discard or Minimize your Dependence on Modern Gadgets

Modern gadgets such as calculators, translation software, spell-check and auto-correct applications may offer convenience but too much dependence on them leaves the corresponding brain synapses that used to do the work highly vulnerable to pruning since they will be rarely used – dulling your mind and diminishing your skill in that field as a consequence.

Engage in some Brain Training Exercises

Just as the body needs physical exercise to stay fit and trim the brain need mental workouts too to remain sharp and responsive. Intense mental workout forces the brain to re-wire itself by way of strengthening and reorganizing synapses and creating neural pathways for it to be able to perform more efficiently. There are a number of neuroplasticity exercises you will find online. The most popular is the Dual N Back exercise.

Dual N-back exercise has been proven by brain experts to improve your memory, your problem solving ability, your quality of sleep, and your imagination. People who have

used this program swear that the program improved their IQ by as much as 18 points. However, it comes with a price. If you are not willing to part with some money just to try this program, you can download the open source version of it which is called Brain Workshop for free.

Engage in Daily Physical Exercise Regularly

Several research studies have shown that engaging in physical exercises stimulates the brain, enhances neuroplasticity, and vastly improves your cognitive abilities. Regular exercise has been shown to boost brain power by increasing brain cell production by as much as 2 to 3 times the regular rate. Besides, a healthy, active lifestyle is also known to prevent or at the very least delay the loss of cognitive abilities due to aging. Physical exercise increases the flow of blood to the brain which enhances neuroplasticity and the creation of new brain cells.

Be Open to New Experiences and seek out Novel Activities

The brain gets excited every time you engage in a new activity. A novel activity triggers the brain to release *dopamine* which aside from being a neurotransmitter is also a trigger to motivate you and prepare you for learning. At the same time, the novel activity stimulates a flurry of successive brain processes. New synapses are created which build on each other to create more synaptic connections which in turn also build more synaptic connections as the learning process for the novel activity is taking place.

Based on this, brain experts believe people with higher intelligence have developed and fortified more neural connections than people with average intelligence. In other words, the individual differences in intelligence can be traced to the number of synaptic connections made between neurons, how these connections affect subsequent connections, and how long these connections will last. By always being a knowledge junkie constantly in search of novel activities to engage with, you will be priming your brain for learning.

Don't stop challenging yourself

You need to keep your brain always on its toes so it won't stop making neural connections and keeping them active. Without stimuli, synaptic connections may become dormant and susceptible to pruning. The best way to keep the brain constantly engaged is to keep challenging yourself too. There are tons of things you can do along this line like taking a new route to the shopping mall, reading a mystery book, or solving a puzzle. Make it a habit to fill your day with mental stimulations.

Remember how a three year old would always ask why? It may sound silly but you can go back to being a three year old and start asking 'why' about everything you come across. This will heighten your own curiosity while at the same time keep your brain engaged.

Network with other People

Networking with other people exposes your mind to many opportunities to grow your cognitive abilities. By interacting with other people face to face or by simply engaging them online via Facebook, Twitter, Google+, or other social media sites, you will be opening yourself to new ideas, new environments, and new people. Mingling with other people outside your own field of interest will give you the opportunity to see things in a new perspective as well as absorb new information in unique and meaningful ways. After all, this is what learning is all about.

Always keep a positive outlook

Never get bogged down by stress or anxiety. Either one of them has been proven to kill your neurons large scale and prevent the generation of new brain cells as well. Instead, you should always think positively. You have to continuously and conscientiously replace negative thoughts with positive thinking. Keeping a positive outlook will not only dramatically relieve stress and anxiety but will also speed up the creation of new brain cells.

Watch what you eat

The food you eat can gravely impact brain plasticity and affect your cognitive abilities. For example, junk foods high in sugar and saturated fats will not only hinder the production of new neurons but will also diminish your cognitive efficiency. On the other hand, eating food rich in brain nutrients like creatine will help increase fluid intelligence. Do some research and find out the best brain food you can eat.

Get enough Sleep

Improving your sleep is one of the best ways to boost your brain power. Loss of sleep results in brain degeneration. On the other hand, having enough sleep will improve your focus, your mood, your attention, your memory retention, and most important of all your thinking ability.

Drink coffee

According to a study, drinking an 8 oz. cup of coffee improves your short term memory and enhances your attention. As a natural stimulant, coffee can energize the sympathetic nervous system. This is the part of the brain that is responsible for cognitive functioning. Coffee is also loaded with antioxidants that can help your neurons to recover from injury and stress.

Eat an apple a day

As the saying goes "*an apple a day keeps the doctor away*". Nowhere is this saying

more relevant than with the brain. The common apple, particularly its skin, contains quercetin, a chemical which is known to have neuroprotective powers. Quercetin guards the brain against cell damage. Apart from apples, quercetin can also found in citrus fruits, red wine, onions, parsley, tea, and sage.

Learn to play an instrument

Learning how to play an instrument is the best brain exercise you can ever have. Whatever instrument you choose, learning how to play one stimulates several parts of your brain at the same time including hearing, visual, motor control, and spatial skills.

Write by hand

Most people nowadays prefer to type on a keyboard rather than write by hand - for convenience and efficiency not to mention precious time saved. What we do not realize however is writing by hand allows the brain to process the information more effectively and retains the knowledge in memory longer. Aside from this, the finger movements related to hand writing activate large portions of the brain particularly the regions that are identified with thinking, language, and memory. So whenever you can, avoid using the keyboard and take out a pen and paper instead.

Quit smoking

Smoking decreases your cognitive ability. The carbon monoxide and free radicals in the cigarette smoke can also reach your brain and suffocate your neurons by denying them the much needed oxygen. Aside from promoting brain cell degeneration, smoking also exposes you to the risk of cerebro-vascular diseases not to mention cancer.