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What is Brain Plasticity? How Does it Work? Why is it Important?

I woke up with my heart wanting to jump out of my chest, beating so fast it made my chest ache. What woke me was my mom crying downstairs in her room, panicking. I instantly knew the reason she was panicking, my little sister, Brianna. My sister had started having seizures recently and the reasons were unknown. Based off of my mom's reaction I knew that this one was the worst one yet. I scrambled downstairs to see if my sister was okay to find my mom outside bawling and my dad giving my sister CPR. After my sister came out of her seizure she wasn't able to talk properly. She would try to say something, but the words came out as jumbled noises. It wasn't until after a couple of minutes of frustratingly trying to speak that my sister was able to talk properly. My parents quickly took her to the emergency room and didn't come home until two in the morning.

Not being able to sleep I got onto google and started researching the causes for seizures. In my research I found many fascinating things about the brain. After that day I kept learning about it, and the more I learned the more I found that I loved it. It was then that I decided that I wanted to pursue a career that involved the brain. After discovering Grey's Anatomy on Netflix and binge watching it that I decided that I wanted to be a neurosurgeon.

Last year when I took AP Psychology there was a large chunk of the class that focused on the brain. It was then that I learned about brain plasticity, though we barely touched on it. Since

then I have always wondered about what exactly it was, how it worked, and why it was important. That is why I chose to take this opportunity to learn more about it.

I decided that a good first step to research is to just start with a bigger picture. I would look up brain plasticity to see all the different topics that would come up to see what I could go into and research more on in order to answer my question. Then I figured once I knew the specifics I wanted to go into, finding articles on those specifics would make finding answers to my question a lot simpler and narrower. I also realized that researching brain plasticity was a good excuse/ reason to finally buy a book that I've been meaning to buy for a while that talks specifically about brain plasticity. In reading it I could get the answer to one or more parts of my question from it. With all this I hope to be able to answer my question in full.

I started by searching the words "brain plasticity" in the brain online to see what would come up. I clicked on BrainFacts.org where I found an article called "what is the brain plasticity, and can it help relieve psychiatric or degenerative brain disorders?" The article explained what plasticity was, and how it was the strongest during childhood. It also talked about how adults still had plasticity, and it showed every time something new was learned. According to the article brain plasticity comes from the Greek word 'plastos', which means molded. This fits perfectly with the meaning of brain plasticity. Brain plasticity is the brain's ability to modify its own structure and function after changes in the body or in the external environment. Plasticity mostly happens in the outer region of the brain – commonly known as grey matter. This answers the first part of my question, what is brain plasticity? Basically brain plasticity would occur if for some reason a part of your brain was damaged. The rest of your brain would teach itself, and take over the function that the damaged part once did. In reading this article I grew curious about why

plasticity was strongest during childhood, so I decided to look into the difference in brain plasticity between children and adults.

I went back to the world wide web and typed in “differences in brain plasticity among children and adults.” I clicked on a link that lead to what seemed a very credible website, the website of the Nation Center for Biotechnology Information. I found the article “Brain Plasticity and Behaviour in the Developing Brian” written by Bryan Kolb and Robbin Gibb, both had PhDs. While reading through the very scientific article and looking up many scientific, I realized they were talking about rats and their brains and then connecting it to human brains here and there. Because of this I couldn’t use the article for information, rats’ brains are different than humans’. The article was also more on experiments done, which were informative, but not very helpful for my research.

I went back to my previous search where I found the article “Brain Plasticity – An Overview” on the website Washington.edu. The article started by going over brain plasticity, which agreed with what I had previously found. Then it went into how the development of the brain as we age plays a big role in our brain’s plasticity. It explained how when babies are born their brains are instantly overwhelmed with sensory input, creating neurological “pathways”. It is in these pathways where synapses occur. The brain consists of neurons that have dendrites and axons. The dendrites’ function is to receive incoming information and bring it into the cell body. Axons take that information and carry it away from the cell body to other neurons where dendrites will then again take in the information. This is what is known as a synapse. At birth there are about 2,500 synapses for every neuron. By the time we reach the age of two there are 15,000 per neuron, twice as much as the average adult. That means information is carried that much faster. This is one of the reasons why plasticity is so much stronger in childhood. As adults

our brains are filled with so much information that certain pathways go unused, forgotten, and gotten rid of so that new pathways can be created. In children this isn't happening because it is during childhood where most information is brought in. Though the making space for new pathways is a sort of plasticity in itself. So this brought me to the next part of my question, how does plasticity work?

I thought that a book all about brain plasticity should have something about how plasticity works so I decided to finally buy *The Brain that Changes Itself* by Norman Doidge, M.D. I went to Barnes and Noble, where I had previously seen the book. Though I wanted to read the entire book, I figured that reading the chapters that focused on what I was looking for was my priority. As I read the book, I found that the information in the book about what plasticity was agreed with the information I had previously found. I also found that how brain plasticity, or neuroplasticity, works is very complicated. Simply put neuroplasticity happens when new neurological pathways are created. These new neurological pathways are created for many different reasons, for the most part they are created when the brain learns something new. For example, when you are first born there is a critical time where your brain develops and learns all the things you need in order to live a functional life. As a baby, your brain gets sensory input from your eyes and starts to create neurological pathways that are the reason why you have eyesight. The book also went into more detail about why children had more plasticity than adults, and it had to do with how neuroplasticity works. As babies, all the neurological paths are barely being created, so learning new things is very easy. As adults our brains are fully developed so in order to create new pathways a process called "pruning back" has to happen.

"Pruning back" is when your brain gets rid of old pathways that aren't used often in order to make space for the new pathways. This is why neuroplasticity is often viewed as competitive.

As children there is no need to make space for new pathways, and is why children have a higher plasticity capacity. This is barely touching the surface of how plasticity works, and to get deeper into how it works goes the next part of my question, why brain plasticity is important.

From *The Brain that Changes Itself* I learned that brain plasticity is relatively new, and took a while for scientists to accept that the brain has plasticity. It was once thought that the brain was a fixed, and so a lot of mental illnesses and brain traumas were labeled as untreatable. Since the discovery of neuroplasticity many of the once thought untreatable illnesses and traumas have treatments. Throughout the book Dr. Norman Doidge writes about many cases where plasticity has brought up a treatment in individuals that once had no hope. From this I got the idea to go to YouTube to see if there were any videos that had individuals' stories on how plasticity helped them. I typed in "brain plasticity" in the search bar and many videos came up. I clicked on one that was titled "Brain Plasticity – the story of Jody." Jody is a little girl who started having seizures at the age of 3 years old, in learning this I listened on with more interest because of my personal connection. Jody's seizures were a lot more severe than my younger sister's, and couldn't be treated with medication. Her seizures were so bad that she lost function of the left side of her body. The doctors suggested a very drastic surgery, to remove all of the right hemisphere of Jody's brain in order to stop the seizures. Ten days later Jody walked out of the hospital. This is possible because of neuroplasticity. The remaining part of Jody's brain changed and learned to do the functions that the right hemisphere was in charge of. It took a lot of therapy, and with each therapy the brain created new neurological pathways as it learned how to be responsible over these new functions. Brain plasticity is important because without it, treatments like these, and illnesses or traumas that were once thought to be untreatable that are now treatable, would never be possible.

Jody's case is very extreme. There are many other cases not as severe, but just as important. Things like the cochlear transplant would never be possible if it weren't for neuroplasticity. A patient regaining the function of her left side after it was once paralyzed from a stroke could never regain that function without brain plasticity. Something as common as learning something new everyday as we go to school wouldn't be possible without plasticity. There many different cases, each just as fascinating as the other. One surprising thing I discovered about neuroplasticity is that it can sometimes bring pain.

As I looked through the chapters in *The Brain that Changes Itself*, I found a chapter that was called "pain, the dark side of plasticity." I immediately decided that this chapter was a must read for my research. The chapter explained how the reason amputees had what is commonly known as phantoms limb pains was because of plasticity. When someone gets a limb amputated, the nerves of that limb get cut off with it. This causes the brain to rewire its brain map, a sort of map that tells the brain and us what part of the brain is in charge of certain sensory input or function, so that a near part of the body is responsible for feeling what the severed limb would feel. In one case an individual felt a constant itch in his phantom limb. Not being able to stand the itch he went to Dr. Ramachandran who had a theory about why phantom limbs occurred. Dr. Ramachandran started feeling near parts of the body to where the amputated limb was with a q-tip. He found that when he touched the individual's cheek, the individual would feel it in his cheek as well as in his phantom limb. When the individual scratched his cheek he would also feel it in his phantom limb and would get rid of the itch. The brain had rewired its map so that what the cheek felt would also be felt as if there was a limb where amputation occurred. Using the plasticity of the brain Ramachandran was able to find a treatment for this individual as well as many other individuals who felt pain in the phantom limbs so that, like the limb, the pain would

be gone too. After reading my chapter I had finished my research, and answered all parts of my question.

Because of personal connection, and fascination in the topic, I wanted to know what brain plasticity was, how it worked, and why it was important. Through many sources I found the answer to all parts of my question. Brain plasticity is the brain's ability to change itself. This is possible because the brain creates new neurological pathways, and sometimes rewiring of the brain's map. This revolutionary idea has many benefits to it seeing as it creates the possibility of treating the untreatable. Though highly beneficial, plasticity can also cause pain to amputees, but even that can also be treated with plasticity itself. Though we know a lot about plasticity, there is still a lot that is a mystery, and is yet to be discovered.

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