On Defining Neuroplasticity: A Book Review of Dr. Norman Doidge's *The Brain That Changes Itself*

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Doidge, N. (2007). *The brain that changes itself: Stories of personal triumph from the frontiers of brain science*. New York, NY: Viking Press.

The Brain That Changes Itself is an international and *New York Times* bestselling book by Dr. Norman Doidge.

It is an excellent recounting of neuroscientific advances and how neuroplasticity does not limit the individual to predefined neural limitations. Doidge presents case study evidence to support the contention that the brain is entirely plastic. Any area of the brain can be "reconfigured" to support a function different from that with which it was "born." He organizes his book with case studies of individuals who have undergone a brain deficit of some kind and examines different types of brain deficits from simple sensory (e.g., auditory and visual) to complex deficits (e.g., missing brain regions; see summary in Table 1).

The central issue that Norman Doidge addresses is the plasticity of the human brain—specifically, to what extent is plasticity possible? In his book, Doidge cites several examples relating to the different senses and cognitive components that show how the brain can reorganize itself to compensate for loss.

In one case study, he introduces Cheryl Sliz who suffers from a vestibular imbalance that made her feel like she was always falling down. Cheryl was fitted with a device on her tongue that sent electrical impulses which essentially "re-trained" her brain for balance. When she started using the device, she

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Table 1. Summary of Neuroplastic Changes Dr. Doidge Reviews in His Book.

Sensory	Motor	Cognitive
Senses – Loss of senses: vision, balance, hearing – Visual problems – Auditory processing problems	Brain injury – Stroke recovery: for speech loss and paralysis – Brain injury recovery: for speech and movement – Major brain problems, such as people born with half a brain Neurological disorders – Autism and hypersensitivity – Cerebral Palsy – Phantom pain and chronic neuropathic pain – Obsessive compulsive disorder	Psychological disorders – Psychological trauma – Cognitive problems that occur after brain surgery – Implications for understanding culture, given that culture rewires the brain – All kinds of learning disorders – Psychotherapy, Psychoanalysis Emotion – Love, sex, and plasticity – Worrying – Depression and anxiety Addiction – Pornography and other addictions Aging – How to preserve an aging brain

found that the period between uses increased indicating that her brain was adapting to the change in information. The remarkable thing about the device is that after about 1 year of use, she never needed the device again.

A similar example is Roger Behm who lost his sight when he was a young man. This device is placed on the tongue, and the blind person is trained to use the device. The touch sensations are translated into visual signals that help Roger see.

Doidge also describes a "cure" for phantom limb pain. He describes the case of Tom who lost his arm. After an exhaustive soccer practice, Tom was driving home when a car from the opposite lane swerved and he was thrown from the driver's seat. As he was flung through the air, he glanced back and saw that his left hand was still in the car. Tom lost his left arm from the elbow down. Even though he knew his arm was gone, he could still feel its presence. He said that he felt he was still able to "wiggle" his fingers and that he felt he was still able to "reach out and grab" nearby objects with his left arm (Ramachandran & Blakeslee, 1998).

Dr. Ramachandran devised the Mirror Box (see Figure 1) which he used to cure Tom of his ailment. When a limb is removed or damaged, the brain will process information from the nearest neurological area—For instance in the brain, the hand area is bordered below the face and above the upper arm and shoulder. These two regions are the locations where "reference fields" are usually found in arm amputees

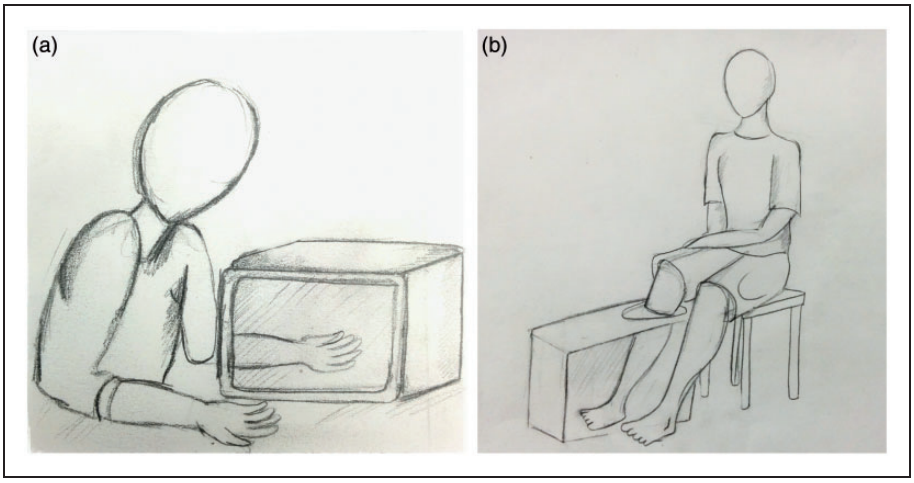


Figure 1. The Mirror Box. The patient puts his intact arm on the side with the mirror and the amputated one in the other side (a) for upper limbs and (b) for lower limbs. In order for this process to work, it is important that the illusion is complete; therefore, no jewelry should be worn on hands or wrists. Tattoos are likely a problem so they would have to be covered on both arms. (Images courtesy of Sherine Elsharnouby.)

(Ramachandran & Hirstein, 1998). The person places their intact limb into one side of the box, and the mirror makes it seem as if both limbs are intact which allows enough time for the therapist to help alleviate the pain.

When a limb goes missing (e.g., hand or foot), the brain still "wants" sensory information from that limb but it is not receiving any because there is no information coming from that limb. The brain, in a sense, steals information from adjacent areas. Brain-imaging studies have confirmed that the primary and secondary somatosensory cortices are involved in the perception of pain. The mirror box and the use of massage can trick the brain into believing the limb is present and, thereby, relieving the pain.

Doidge goes even further with his compelling tales to describe how psychoanalysis could be a form of neuroplastic therapy. He describes the case of Mr. L who was an alcoholic with a 40-year history of depression and string of affairs. Mr. L also had no memories from childhood.

Doidge believes that psychoanalysis changes the brain right down to the genes. By changing the way someone thinks, you can change their genetic makeup (epigenesis). Epigenetics is the study of heritable changes caused by mechanisms outside those inherent in the DNA sequence. Epigenetics views genes as collaborative, that is, not determining an individual's traits independently but associatively.

He supports this belief with research by Kandel's classic Aplysia experiments. Dr. Eric Kandel was able to show that as a snail (i.e., the Aplysia) learned to avoid shocks and withdraw its gill, its nervous system changed, enhancing the connections between its sensory and motor brain cells, and giving off more powerful signals detected by the microelectrodes. This was the first proof that learning led to neuroplastic strengthening of connections. It was then suggested that memory could be considered a long-lasting change in the efficiency of the communication of these brain cells.

One of Doidge's more impressive stories is that of Michelle Mack. Dr. Jordan Grafman at the National Institutes of Health describes Michelle's brain as follows:

> Mack's right hemisphere controls tasks handled by the left brain in other people. But this compensation comes with a price; she struggles with visual-spatial tasks, which are normally processed in the right brain. It's as if the two abilities, linguistic and visual-spatial, had to "duke it out" for space in her brain—and language won.

This is one of the primary drawbacks of Doidge's argument of neuroplasticity. By the end of the book, Doidge seems to realize there are limitations to neuroplasticity. Our goal, as scientists, is to determine those limitations and how an individual can succeed and another fail with the same disadvantage.

The book presents some very good case studies, however, this leads to the main issue I had with this book. All the examples are case studies and very few indicate any evidence of follow-up.

Case studies can also fail. A presentation at Carleton University, Ottawa, Canada, in October 2013 given by Dr. Kirsten Dalrymple of the Institute of Child Development at the University of Minnesota in her talk on prosopagnosia showed that a person could train herself to recognize faces but when she stopped training, she lost the ability. These cases are important because they can help delineate the boundaries and restrictions to neuroplasticity. For instance, in this case, one might ask was the training long or intensive enough to be retained, was the person's age a factor, or were the more dominant brain regions re-taking the temporarily trained region. One side note that also requires some attention, when the patient was re-trained, it took fewer trials than the initial training period. Researchers DeGutis et al. (2007) believe that this may be due to reverting to her default mode network. The default mode network is a brain network that is active during "wakeful rest" (e.g., daydreaming and retrieving memories).

So when brain training fails, is it because the training cannot occur or because one of the factors of the training is not properly employed? By looking at cases when brain training fails, you can examine why it may not have worked. It may be the wrong exercise (for example, when the stroke patient in Doidge's book was retraining his brain, he did not start out by trying to walk—that exercise would have been too advanced for the damage, therefore, the exercise was

manipulated to find the optimum response threshold). Another method, other than case studies, would be to cease training and see if the plasticity holds. If not, how long does it remain before relapse? Finally, performing imaging studies could help determine the rate and, perhaps reason for degradation of a brain area that had previously improved.

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