Brain Plasticity

Rachel Wu, Ph.D.
University of California, Riverside

For decades, it was assumed that people are born with a certain number of neurons in the brain, and these neurons slowly died off with age. However, scientific studies have shown that the infant brain goes through very dramatic changes in the first few months and years of life (including adding additional neurons), and the brain can recover (although perhaps not fully) after a traumatic brain injury or stroke. Very recently, it has even been shown that new neurons can grow in the healthy adult brain. Brain plasticity involves long-lasting changes due to generation of new neurons, as well as other structural changes, such as axonal growth and increases in myelin (the fatty white tissue surrounding the neurons that allows for more efficient transmission of information). Among the first to support the idea that the brain is malleable in later periods of the lifespan was Ramon y Cajal at the beginning of the 19th century. But it is only recent that the concept of plasticity in adulthood has become more widely accepted with the increase in experimental studies and the invention of advanced neurological techniques, especially magnetic resonance imaging (MRI) with human adults. This entry will provide a brief overview of theories of brain plasticity in human adults and experimental studies that provide evidence for these theories.

Dr. Martin Lövdén and colleagues developed an important theoretical model that explains the phenomenon of neuroplasticity using a supply-demand framework. In this model, plasticity is a result of a mismatch in environmental demands and the brain's ability to meet these demands. Essentially, the idea is that the brain will meet the environment demands that are present for a prolonged period of time. If the demands are higher than the brain's ability, then the brain will adjust by generating new neurons and increasing connectivity. If the demands are lower than the brain's ability, then the brain might lose neurons, connectivity, and therefore, functioning over time. The latter is often referred to as "use it or lose it." According to the theory, the ability to adjust to increased environmental demands is thought to decline with age, as external demands lessen with time, and the metabolic cost of frequently exhibiting plastic changes becomes increasingly taxing on an individual’s brain. According to some researchers, this decline is a result of more inhibition than excitation later in the lifespan, while it is the opposite earlier in the lifespan. For older adults to return to a state whereby the brain can grow and develop, researchers have proposed that the excitation-inhibition balance experienced from childhood to early adulthood needs to be reintroduced. Enriching and stimulating environments, such as learning new skills, are thought to be an effective way of obtaining this balance.

In addition to theoretical models, many studies have provided empirical evidence of neuroplasticity. In one study, both younger and older adults were assigned to either a training or control condition. Those in the training condition were given several memory tasks that required participants to recall items, such as letters and colors, to practice for five weeks. At the end of the study, both older and younger participants performed higher on the memory task involving letters (i.e., criterion task) than those in the control condition. Moreover, in an intervention, older adults more at risk for cognitive impairment were asked to assist grade school teachers in designated tasks, ranging from library support to conflict resolution, over the course of one year. Results showed that those in the intervention versus the control condition (no training) performed better on an inhibition task, and fMRI results displayed increased activation in prefrontal regions of the brain, which are typically involved in planning, decision-making, and multi-tasking abilities. In another study where older adults were asked to learn how to juggle for three months, the findings revealed an increase in the various brain regions (e.g., hippocampus and visual cortex) compared to those in the control group. In a study involving adult mice, greater neural growth in the hippocampus was found for those living in an enriched environment, such as with extra toys, compared to those that did not. Similar results were found in another study, where more physically active adult mice had less neural loss in the hippocampus than those that were more sedentary.

Although plasticity is a phenomenon that is most prevalent throughout the earlier stages of the lifespan, new evidence has demonstrated that neuroplasticity can be achieved simply via changing external demands, even during adulthood. These findings suggest that it is still possible to "grow" your brain during later stages of life.

Further Reading

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. *Journal of Neuroscience, 30*(45), 14964-14971.

Boyke, J., Driemeyer, J., Gaser, C., Büchel, C., & May, A. (2008). Training-induced brain structure changes in the elderly. *Journal of Neuroscience, 2*8(28), 7031-7035.

Berlucchi, G., & Buchtel, H. A. (2009). Neuronal plasticity: historical roots and evolution of meaning. *Experimental Brain Research, 192*(3), 307-319.

Lövdén, M., Bäckman, L., Lindenberger, U., Schaefer, S., & Schmiedek, F. (2010). A theoretical framework for the study of adult cognitive plasticity. *Psychological bulletin, 136*(4), 659.