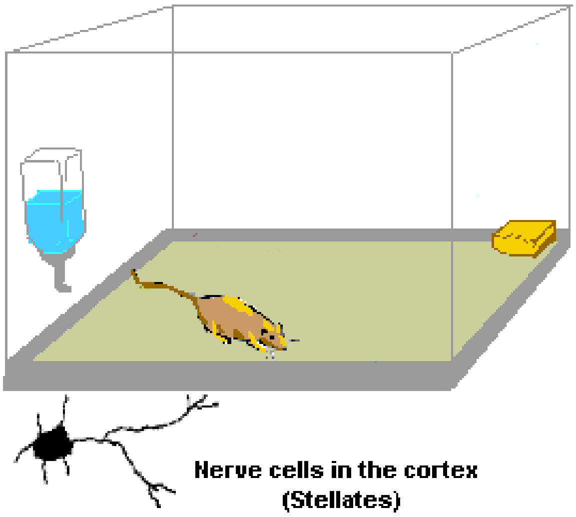
Learning and Changes in the Brain

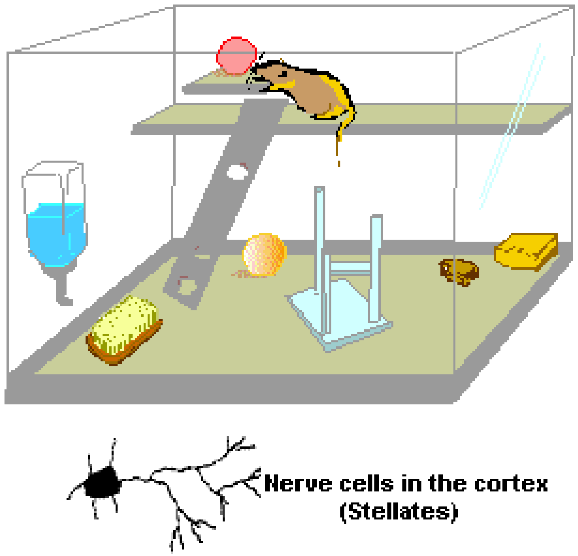
By Silvia Helena Cardoso, PhD and Renato M.E. Sabbatini, PhD

Until recently, neuroscientists believed that once the brain completes its development, its is unable to change, particularly in regard to its neural cells, or neurons. The dogma held that neurons cannot reproduce themselves or change significantly their connection structure to other neurons. The practical consequence for these tenets were that a) lesioned parts of the brain, such as in victims of tumors or stroke, are unable to growth again and regain part of their function; and b) experience and learning may alter the brain's functionality, but not its anatomy.

It seems that neuroscientists were wrong on both counts. Research in the last 10 years shows a strikingly different picture. In response to play, stimulation and experience, there is a growth of neural connections within the brain. Although early pioneers in biobehavioral research, such as Donald Hebb, from Canada, and Jersy Konorski, from Poland, believed that memory probably involved structural changes in the neural circuits, experimental evidence for this notion was lacking.

In experiments carried out in rats by American neuroanatomist Dr. Marian Diamond, she was able to show that animals that were reared in a rich environment -- a cage full of toys and features such as balls, wheels, staircases, ramps, etc., developed a significantly thicker cerebral cortex than rats reared in a poorer environment, without toys, or in isolation. The increased thickness was due not only to a larger number of brain cells, but also there was more extensive branching of their dendrites and of interconnections to other cells.

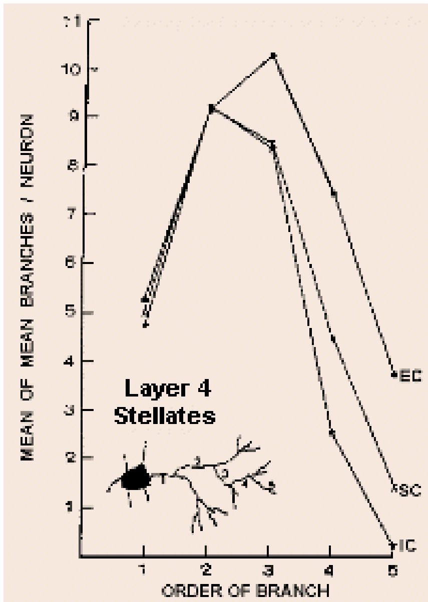




Feature poor environment

Enriched environmental allowing rats to interact with toys in their cage produces anatomical changes in the cerebral cortex.

The graph on the right shows how the mean number of branches observed in stellate cells, which are found in the fourth layer of the rat's visual cortex, increase more on animals reared on rich environments (curve labelled EC, or enriched condition), than in animals reared together in social groups, but with no toys (SC, or social condition group). SC rats, on the other hand, have more branching in the stellate cells than animals reared isolated, and without toys (IC, or isolated condition group). A larger difference between the groups can be seen on the 4th and 5th level branches. In other words: branches arising from the cell's body do not get increased because of rich sensory, motor and social experience; but branches at the tip of long processes, do. This is evidence that the stellate cells are growing and extending new sub-branches on existing ones, and this is revolutionary knowledge.

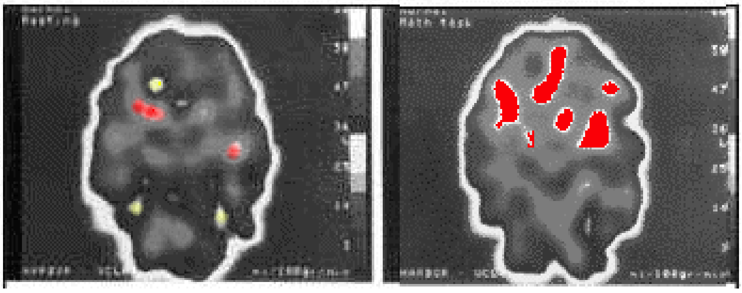


The parts of the stellate cells which are growing are the dendrites. It is through the dendrites that a neuron receives nervous impulses from other cells, which are conveyed to the cell's body, and thence to the axon. Therefore, a growth in dendrite branching can only mean that intercommunication processes in the cortex cells have increased and that more dendrites make them more effective in terms of regulating the activity of neural circuits.

Does this growth happens in humans, too?

It seems so, although direct evidence, such as that observed by Diamond in rats, is not available yet. However, we know that mental activation tasks are accompanied by many changes, such as in brain metabolism (consumption of glucose by brain cells, increase in blood flow and temperature, etc.). These changes can now be observed directly by using

computerized imaging devices, such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET).



Cerebral Blood Flow (CBF) during a mental activation task. Normal control subject, baseline (left) and mathematical task (right). In this subject, increased perfusion during the mathematicaltask is present in both inferior frontal and left parietal areas.
Source: Villanueva-Meyer et. cols. - Alasbimn Journal

The practical consequences for the knowledge that brain cells grow and modify themselves in response to rich learning and experience are extraordinary:

1. Rearing kids in a rich sensory environment from very early age may have an impact on their cognitive and memory capabilities later in life. Adding color, music, sensations (such as baby massage), lots of interaction with pals and relatives of several ages, exercising the body and the mind, etc., may be beneficial (if not done in excess, of course). In facts, there are many studies about "early stimulation" in children, showing that this is true. We still have to determine whether this leads to increased growth in the kids' brains, as it happens with rats, but there is little doubt;
2. People who got parts of their brains lesioned may recover part of the lost functions by being subjected to intense and diverse sensory and mental stimulation, in analogy to physical therapy for weak muscles;
3. Foodstuffs or artificial drugs that enhance dendrite branching and neuron growth and increase in size may help in augmenting mental performance and memory in normal people or patients with degenerative diseases of the brain, such as Alzheimer.

In fact, a pioneering study done by Dr. David Snowdon, a neuroscientist from University of Kentucky, with Catholic nuns living in a convent in Northern USA, has disclosed startling facts which support the brain stimulation theory. These nuns were selected for the study because they seem to show a much longer longevity than the overall population: several of them have reached more than 100 years of age. The sisters who lived longer and in better mental health where almost always those who had hobbies, such as painting, teaching or doing crossword puzzles, which lead to a constant "mental exercise". In fact, Dr. was surprised to see in post-mortem examinations of the brains donated by the deceased nuns, that some of those who were in best mental conditions because of this rich stimulation, had all telltale signs of encroaching Alzheimer's Disease. This highly incapacitating neural degenerative disease appears in almost 20% of all people beyond 80 years old, and is characterized by a number of pathological alterations inside neurons, and the massive death of cells, mainly in the cortex. This leads to deep memory loss, and other kinds of deterioration of behavior and personality.

Conclusions

Neural growth and regeneration in response to environmental factors no longer appear to be impossible, from what neuroscience has disclosed in experiments with animals and humans. This knowledge, coupled with the discovery of the mechanisms that make this possible will be the gateway to a fantastic future for humankind; a future where we may well be able to manipulate and influence our own mental capacities in unforeseen ways. This has been a long-standing dream of fiction and science alike, and we may be in the threshold to its realization.

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