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Neuroplasticity, Neuroscience and Cortical Mapping: A General Introduction

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***Abstract*—** Also called brain plasticity, this term includes both synaptic and non-synaptic plasticity. Synaptic plasticity is related to changes in neurotransmission pathways and also some synapses associated with changes in the body's behaviour, environment and neural processes, as well as changes following physical injury. Neuroplasticity manifests at various levels, from cellular changes induced by learning to systemic changes in the cerebral cortex in response to an injury. It highlights the role of neuroplasticity in healthy development, learning and memory, as well as recovery after a brain injury. During the twentieth century, the views of most neuroscientists were in agreement that the brain remains stationary after the end of human development (or what they call the end of the critical period, which means the stage during which the organism passes and does not develop sufficiently, after which it is difficult to repair the defect and this stage is in the beginning of childhood). The study of neural plasticity allowed us to dispel the previous hypothesis that the brain is a static physiological organ and allowed us to explore the ways in which the brain changes during our lifetime with reference to the many findings that demonstrate brain plasticity even in adulthood.

***Keywords*—** Iron Ore – Steel – Manufacture – Uses - mining

I. Introduction

Hubble and Wiesel demonstrated that the columns of ocular neurons in the primary visual cortex V1, were highly stable after fetal development, and studies demonstrated the stability of neurosensory pathways in that region as well. But other studies have shown that environmental change can alter behavior and cognition by modifying connections between neurons or even creating new neurons in, say, the hippocampus and cerebellum, or in other parts of the brain. Decades of research have shown significant changes in the information-processing regions located at the bottom of the neocortex that dramatically alter the pattern of neuron activation in response to a person's experiences.

Neurological research indicates that a person's experiences can change the brain's anatomical and physiological structure, and research now continues with an ongoing discussion between studies that see brain stability after a critical period and recent findings that prove brain plasticit.

One of the fundamental principles of how neuroplasticity functions relate to the principle of synaptic pruning, the idea that individual connections within the brain are steadily removed or created. It largely depends on how you use it. This principle is quoted from the proverb "Nerves that act together, communicate together" / "Nerves that act in part, are connected in part". Summarizes Hebbian theory. If there are two adjacent neurons that normally produce impulses simultaneously, their cortical maps may become one. This idea works in the opposite direction, too. This means that (in other words) nerves that do not periodically produce instantaneous impulses will form different maps.

II. CORTICAL MAPS

Cortical organization, especially for the sensory organs, is described by the term "maps". For example, sensory information maps from the foot to one cortical side and maps from the hand to the other. As a result of this somatosensory organization of sensory input to the cortex, the cortical representation of the body becomes similar to a map (or dwarf). Various groups in the late 1970s and early 1980s began to explore the effects of removing portions of sensory input. Michael Merzenich, Jon Kaas, and Doug Rasmusson used cortical maps as a dependent variable. They found that - given it has been proven in a wide range of laboratories - that if cortical maps are deprived of their input, they will be activated at a later time in response to other inputs that are normally adjacent to them. Merzenich (1984) study of maps of owl monkey hands before and after third finger amputation. Prior to the amputation, there were five distinct areas, each one identical to each finger of the experimental hand. 62 days after the amputation of the third finger, the area in the cortical map that was previously occupied by that finger was invaded and occupied by the second and fourth digits previously adjacent to the amputated finger. The regions representing the first and fifth digits are not located directly next to the region representing the third digit, and therefore these regions remain, for most of this part, unchanged after amputation. This study clearly shows that only areas adjacent to a specific area will invade to replace the cortical map. In the somatosensory system, where this phenomenon has been investigated in every sense of the word, Wall Jt and J Xu have traced the mechanisms underlying this plasticity. Reorganization is not cortically generated, but occurs at every stage of the developing sequence; this results in changes in the map becoming noticeable in the cerebral cortex. Merzenich and William Jenkins (in 1990) began studies of sensory experience, without pathological disruption, to note cortical plasticity of the somatosensory system of primates with the conclusion that sensory sites are activated by an increase in reinforcement behavior related to their cortical response. Shortly thereafter, Ford Ebner and colleagues (1994) performed similar experiments on the barrel cortex of the nose hairs (whisker) of rodents (also the somatosensory system). These two groups have differed greatly over the years. Rodent drinker experiments have become a focus of Ebner, Matthew Diamond, Michael Armstrong James, Robert Sachdev, and Kevin Fox and they have had significant success in locating changes in cortical synapses that express NMDA receptors involved in cholinergic inputs as necessary for normal expression. However, studies of rodents have focused weakly on the behavioral end, and Ron Frosting and Daniel Polley (1999, 2004) have identified the behavioral maneuvers that cause the primary effect on cortical plasticity in this system. Merzenich and Black (2002, 2005, 2006) used cortical implants again to study the growth of neuroplasticity in both the auditory system and the cutaneous sensory system. Both devices showed similar changes with respect to behaviour. When cognitive stimulation and reinforcement are combined, the cortical response appears to be reinforced and expanded. In some cases, the response may increase from two to three times within a day or two. At the time, the motor sense requires a new behavior, and these changes disappear completely within a few weeks. The observational studies showed that these changes do not occur in the sensory experience alone, but that they need to learn about the sensory experience, and more motivational force accompanying the response, and that they occur with a nature equal in operation to normal behavioral states.

An interesting phenomenon involved in cortical maps is phantom limbs. This phenomenon is known in people who have undergone amputations, whether in the hands, arms or legs, but it is not limited to the limbs. The neural basis for this phenomenon has not yet been studied, but it is believed that cortical reorganization plays an important role. Norman Doidge, under the guidance of Michael Mersnick, divided the manifestations of neural plasticity into positive or negative coping behavior. As a result, for example, if a person recovers after a stroke and functions normally, it can be considered an example of positive plasticity. As for the occurrence of changes such as increased neuronal growth, which leads to convulsions and tonic paralysis, or excessive release of neurotransmitters in response to nerve damage, which may lead to the death of neurons, it can be considered negative plasticity. In addition, drug addiction and OCD are significant examples of negative plasticity, according to Dr. Dodge. The re-formation of new synapses after a stroke results in such behaviors and severe mismatch. A 2005 study showed that the effects of neuroplasticity occurred faster than previously expected, as the brains of medical students were scanned during the period of their exams and within a month, the gray matter had increased significantly in the lateral and posterior parietal cortex.

III. NEUROPLASTICITY APPLICATIONS AND EXAMPLES

Brain damage treatment

A surprising consequence of neural plasticity is that brain activity related to one of its functions can be shifted to a different location. This results from natural experience and also occurs in the healing process of brain injury. Neuroplasticity is the main issue that underpins the scientific basis for treating acquired brain injury with experimental target-oriented therapeutic programs in the context of rehabilitation methods for the functional consequences of the injury. The adult brain is not wired with fully stable nerve circuits. There are many examples of cortical and subcortical structures of neuronal circuits arising in response to training as well as in response to injury. This is solid evidence of neurogenesis (birth of neurons) in the adult mammalian brain—and such changes persist well into advanced age. Evidence for neurogenesis is mainly confined to the hippocampus and the olfactory bulb, but current research has revealed that other parts of the brain such as the cerebellum are also involved in this process.

In the rest of the brain, nerves can die but not regenerate. However, there is now enough evidence for activity, based on experience, to reorganize the brain's synapses, involving overlapping structures that include the cerebral cortex, and the finer details of how this process occurs at the molecular and structural levels. Flours are active topics for neuroscience researchers. The manner in which experience can influence the organization of synapses in the brain is also the basis for several theories of brain functioning, including the general theory of mind and epistemology dating back to neuro Darwinism and developed by the Nobel Prize-winning immunologist Gerald Edelman. The principle of nerve plasticity is also the basis for synapse structure and function in the study of classical conditioning in invertebrate animal models such as Aplysia. This latest program of neuroscience research has emerged from the ground-breaking work of two other researchers, Nobel Prize winner Eric Kandel, and several colleagues at Columbia University's College of Physicians and Surgeons.

Paul Bach-y-Rita, deceased in 2006, is considered the "father of sensory substitution and brain plasticity." Working with a patient with a damaged vestibular apparatus he developed the BrainPort, a machine that "replaces her vestibular apparatus and will send balance signals to her brain from her tongue." After using this machine for some time it was no longer necessary, as it regained the ability to perform normally. The days of balancing her are over.

Plasticity is the most important explanation for this phenomenon. Because the vestibular system was "disturbed" and sent random signals rather than coherent ones, the vestibular system was able to find new ways around damaged or blocked nerve pathways, helping to enhance the signals sent by the rest of the healthy tissue. Bachhi Rita explained plasticity by saying, "If you drive from here to Milwaukee and cross the main bridge road, first you're helpless. Then you take the old, secondary roads through the farms. Then you use those roads more; you find roads Shorter to get where you want to go, and you start to get to your destination faster these "secondary" neural pathways become "unfold" and become stronger with continued use. The process of "unfolding" is generally believed to be one of the primary methods by which the plastic brain distinguishes itself.

Randy Nudo's group found that if a small stroke (infarction) occurs by obstructing blood flow to a part of the cerebral cortex of a monkey, the part of the body that responds with movement will move when the areas adjacent to the damaged brain regions are stimulated.

In one study, intracortical microstimulation (ICMS) mapping techniques were used in nine monkeys. Some underwent cerebral infarction - while others underwent ICMS. Monkeys with cerebral infarction retained more finger flexion during food retrieval, and after several months this returned. deficit to pre-operative levels.

Regarding the distal forelimb representations, the infarct mapping showed that the movement representations underwent reorganization in all areas of the adjacent undamaged cortex. "Understanding the interaction between damaged and undamaged areas provides the basis for better treatment plans for stroke patients." Current research includes tracking changes that occur in motor areas of the cerebral cortex as a result of a stroke.

Thus, events that occur in the process of brain reorganization can confirm this. The NODO Group is also involved in studying treatment plans that may promote stroke recovery, such as physical therapy, pharmacotherapy, and electrical stimulation therapy.

Neuroplasticity is gaining popularity as a theory, at least in part, that explains improvements in functional with physical outcomes in post-stroke treatment. Rehabilitation techniques that have evidence to suggest cortical reorganization as a mechanism of change include restriction-induced movement therapy, functional electrical stimulation, vacuum training with body weight support, and virtual reality therapy. Robot-assisted therapy is an emerging technology, which is also supposed to work alongside the neuroplasticity method, although there is currently insufficient evidence to determine the exact mechanisms of change when this method is used.

John Cass (a professor at Vanderbilt University) was able to show how somatosensory 3b, ventral posterior (VP), and thalamic nuclei were affected by prolonged unilateral dorsal column injury at cervical levels in macaques. " Adult brains have the ability to change as a result of injury, but the extent of the reorganization depends on the extent of the injury. His current research focuses on the somatosensory system, which involves feeling and moving the body using several senses. Usually when people's somatosensory cortex is damaged, all perceptions of physical weakness will be experienced. He is trying to see how these systems (the somatosensory, the cognitive, and the motor systems) are resilient as a result of the injury.

One of the most recent applications of neuroplasticity includes work done by a team of clinicians and researchers at Emory University, in particular Donald Stein, Dr. Donald Stein (who has worked in this field for three decades), and Dr. David Wright. David Wright. This is the first treatment in 40 years that has led to significant results in the treatment of traumatic brain injury while also not causing known side effects and being inexpensive in application. Dr. Stein noticed that female mice appeared to recover from brain injury better than male mice. He also observed in females at certain points in the estrus cycle that these females recovered more. After much research, this difference has been attributed to progesterone levels. The higher level of progesterone led to the faster recovery of brain damage in these mice. They developed a treatment that involved increased levels of progesterone injections to give to patients with brain damage. “Administration of progesterone after traumatic brain injury (TBI) and stroke reduced edema, inflammation, and neuronal cell death, and improved spatial reference memory and sensory motor recovery.” In their clinical trials, they had a group of patients who, three days after progesterone injections, experienced 60% reduction in the death rate. The example occurred in a terrible traffic accident that left the patient with marginal brain activity; According to the doctors, the patient was on the way to brain death. The patient's parents decided to include their son in Dr. Stein's clinical trial and he was given a three-day progesterone treatment. Three years after the accident, the patient has achieved an impressive recovery without brain complications and the ability to live in good health.

Dr. Stein conducted several studies on old mice, which gave results similar to those conducted on young mice. (Whereas progesterone was stable in young, non-aging mice) But with the modification of the experiment, since there were physiological differences between the two groups of mice in terms of age, the old mice were modified by lowering their stress with more physical contact. During the surgical procedure, the anesthesia was kept in a high level of oxygen with a low level of isoflurane. Aging mice before surgery were given a lactated ringer’s solution subcutaneously to replace fluid lost with increased bleeding during surgery.

The promising results of progesterone therapy may have an important bearing on clinical measures currently taken for TBI patients. It also appeared that these treatments give results in human patients if they are applied immediately after the injury. But for now, Dr. Stein is focusing his research on patients who have had (long-term) damage in order to determine whether progesterone therapy can reverse the impaired function.

Vision

For many decades, it was assumed that the skill of binocular vision in a particular object must be learned in the early stages of childhood, but after that it can never be learned. However, in recent years it has been found that there are results contrary to that assumption. The successful improvements observed in patients with amblyopia, patients with convergence insufficiency and those with abnormalities in stereoscopic vision were prime examples of the effectiveness of neuroplasticity. These improvements in strabismus patients and those who suffer from a defect in stereoscopic vision, now occupy an important space in scientific and clinical research.

Handling learning difficulties

Michel Ferzenich developed a set of "softness-based computer programs" known as Fast For Word [citation needed]. This program provides seven brain exercises to help, along with education and language, with dyslexia difficulties. Recent studies have been conducted in adults to see if this aid can counteract negative plasticity and the consequences of age-dependent cognitive decline (ARCD). The ET design includes six exercises designed to reverse ARCD dysfunction in cognition, memory, motor control, and so on. After using the ET program for 8-10 weeks, he will notice a significant increase in the performance of a specific task[citation needed]. The information collected from the study indicated that the program based on neuroplasticity can significantly improve cognitive functions and memory in adults with ARCD.

During the operation of the mediator of the brain machine

The brain-machine interface (BMI) is a rapidly developing field in neuroscience. According to the results obtained by Mikhail Lebedev, Miguel Nicolelis and their colleagues, the operation of the brain-machine interface results in the integration of an artificial motor into the representation of the brain. The scientists demonstrated that modulation of neural representation in the monkey's hand and the motor that was being controlled by the monkey's brain appeared in multiple cortical locations while the monkey was operating the brain's mediator. In today's experiments, monkeys triggered the actuator first by depressing the steering knob. After mapping the motor neuron ensemble, the motor control was switched to the ensemble model, letting the activity of the brain, not the hand, directly control the motor. The animals would eventually be able to stop moving their hands and still be able to keep the engine running. So, while controlling the brain-machine-mediator BMI, cortical ensembles adapt plastically, within tens of minutes, to represent behaviorally observed kinetic parameters, even if they are not related to the movements of the animal's limb.

Active lab groups include those of John Dono at Brown, Richard Andersen at Caltech, Krishna Shinoy at Stanford, Nicholas Hatsuboulos at the University of Chicago, Andy Schwartz at the University of Pittsburgh, Sandro Mosalvaldi at Northwestern University and Miguel Nicolelis at Duke University. The Dunno and Nicolelis groups showed, independently of each other, that animals can control an external mediator in tasks that require a response, with models based on the activity of cortical neurons, and that the animals can adaptively change their minds to make these models work better. Donog's group received implants. from Richard Norman's lab in Utah ("Utah"), improved it by changing the dielectric from polyimide to parylene-c and traded it through Cyberkinetics. These efforts are the leading candidates for first large-scale human trials of motor cortical implants to help patients with quadriplegia or locked-in syndrome to communicate with the outside world.

Sensory suits

Neuroplasticity falls within the development of sensory function. Where the brain in fetal life is immature, but after birth it acquires sensory information. In the auditory system, hearing impairments are fairly common, affecting 1 in 1000 newborns, affecting their hearing development. Implanting sensory substitutes that activate the auditory system prevented the deficit and stimulated the functional maturation of the auditory system. According to the sensitive period of neuronal plasticity, there is also a sensitive period for other interventions during the first 2-4 years of life. As a result, cochlear implants early in deaf-mute children enable them to learn the mother tongue and gain auditory communication.

Phantom parties

Phantom limbs are a phenomenon that we find in people who have had a part of their body amputated, where the feeling of pain or feeling for that part of the body continues despite the amputation. This phenomenon is strangely common, it is found in 60-80% of cases. One explanation is that it is due to neural plasticity. Cortical maps of amputated limbs are thought to correlate with surrounding cortical areas in the retrocentral gyrus. This leads to activation of cortical regions surrounding the original region of the amputated limb that are misinterpreted (activated) after the limb is absent.

The relationship between phantom limb phenomenon and neuroplasticity is rather complex. In the nineties of the last century, the scientist Ramachandran put forward a theory that says that the phenomenon of phantom limbs is caused by the rearrangement of the cortical map. But in 1995 Herta Flor and her colleagues showed that this rearrangement occurred only in patients with phantom pain for their amputated limb. Her research showed that phantom pain (rather referred sensations) is a perceptual correlate of this cortical reorganization. This phenomenon is also sometimes attributed to maladaptation of neuronal plasticity.

In 2009 Lormer Moseley and Peter Bruger conducted an amazing experiment in which they encouraged hand amputees to use visual imagery to bend a phantom limb into impossible poses. Four out of seven people succeeded in getting the fictitious party to perform these impossible movements. This experience indicates that these subjects modify the neural representation of their phantom limbs and generate the motor commands required to carry out the impossible movements in the absence of reflexes from the body. The authors declare: "Indeed, these findings extend our understanding of neural plasticity because they are evidence that profound changes in the mental representation of the body can be stimulated by purely intrinsic brain mechanisms -- the brain really does change itself."

Chronic pain

People who suffer from chronic and continuous pain in places that were previously hurt, despite their recovery at the present time. This phenomenon is due to neural plasticity resulting from inappropriate reorganization of the peripheral and central nervous systems. During the period of tissue damage, due to inflammation and harmful excitation, an increase in painful energy occurs from the peripheral to the central nervous system. Continuous damage from the periphery will cause a neural response at the cortical level to change the somatic organization of the pain site, including central sensitization. For example, subjects with compound regional pain syndrome showed decreased cortical body representation of the contralateral hand as well as decreased hand-mouth spacing. In addition, it has been universally reported that chronic pain is due to a clear decrease in the volume of gray matter in the brain, especially in the prefrontal cortex and right hypothalamus, but after treatment these abnormalities in cortical reorganization and in gray matter volume as well as the resulting symptoms will subside. The same results were reported in phantom terminal pain, chronic low back pain, and carpal tunnel syndrome.

Meditation

A number of studies have linked meditation practice to differences in cortical thickness or gray matter density. One of the most well-known studies to prove this was led by Sarah Lazar, of Harvard University, in 2000. Richard Davidson, a neuroscientist at the University of Wisconsin, led experiments in collaboration with the Dalai Lama on the effects of meditation on the brain. His results indicate that long-term or short-term practice of meditation results in different levels of activity in areas of the brain associated with these traits of interest, anxiety, depression, fear, anger, and the body's ability to heal itself, and so these functional changes may be due to changes in the physical structure for the brain.

Fitness and exercise

In a 2009 study, scientists had two groups of mice swim in a water maze, and then in a separate experiment exposed them to an unpleasant stimulus to see how quickly they learned to walk away from it. Then, over the next four weeks they allowed one group of mice to run inside the rodents' wheels, an activity most mice enjoy, while they forced another group to work harder on the little treadmills at the speed and duration the scientists set. Then they tested both groups again to track learning and memory skills. Both groups of mice improved their performance in water mazes from the previous experiment. But only the outside treadmill runners worked better at an avoidance task, a skill that, according to neuroscientists, requires a more complex cognitive response.

Mice who were forced to run on treadmills showed evidence of molecular changes in several parts of their brains when viewed under a microscope, while the voluntary wheel runner group showed changes in just one area. "Our results support the idea that different forms of exercise stimulate neuroplasticity changes in different brain regions," said Chauying J. jen, professor of physiology and author of the study. At the same time, similar results appeared in humans.

Human echolocation

Known as the learning ability of humans to sense the environment around them through echoes. Blind people use this ability to navigate and sense their surroundings in detail. Studies conducted in 2010-2011 using magnetic resonance imaging techniques showed that the parts of the brain associated with visual processing adapted to the new skill of echolocation. For example, studies conducted on blind patients indicate that the click echo heard by patients is processed through areas of the brain dedicated to vision rather than areas of the auditory.

IV. CONCLUSION

In the sixties, the scientist Paul Bach y Rita invented a device that allows the blind to read, perceive shadows and distinguish between near and far objects. This device was one of the first and most daring applications in the field of neuroplasticity. It is an electric chair on which the blind sit, equipped with a large camera behind it that scans the surrounding area, then sends electrical signals about the image to 400 vibrating sensors connected to the chair and touching the patient's skin. The six subjects of this experiment were eventually able to make the patient able to discern very subtle things. These patients were congenitally blind and had never been able to see. Scientist Eleanor Maguire has documented evidence of changes in the structure of the hippocampus in local taxi drivers in London, who should know London's road organization. Where a redistribution of gray matter was observed in them. This notion of hippocampal plasticity has preoccupied not only scientists but also official and international media. The scientist Paul Bach y Rita believed in the so-called "sensory substitution", that is, if a feeling is hurt, the other senses can sometimes compensate, and the skin and its tactile receptors can act as a human retina (using one's sense for the other). In order for the brain to interpret tactile information and turn it into visual information, it must learn something new and adapt to new signals. The ability of the brain to adapt includes having neural plasticity, according to him. He says: We see with our brains, not with our eyes. It was a tragic stroke that paralyzed his father and inspired Paul Bach to study brain rehabilitation. His brother, the doctor, worked tirelessly to develop remedial measures that were so successful that their father could regain his full function and live normally at the age of 68. He could even climb mountains. Their father's story was direct evidence that even an elderly person with a major injury can recover, even if recovery is delayed.

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