The Visual System

1981 Nobel Prize Medicine (Part 1)

David H. Hubel and Torsten N. Wiesel were co-recipients of the 1981 Nobel Prize in Medicine or Physiology for their discoveries concerning the visual system.

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Hubel and Wiesel also showed that visual impulses need to undergo progressive analysis and integration before other parts of the brain can create emotions and memory relevant to the visual stimuli.

Background

During the 1950's, very little was known about the complexity of the visual system. Very few researches were conducted regarding the mechanisms behind our sense of vision. In the early 1950's, Hartline tried to spark an interest in this field when he discovered that the visual input received the retina are divided, fine-tuned and sharpened along its pathway towards the visual cortex.

In the following years, Hubel and Wiesel tried to continue on this pioneering research and were surprised by the degree to which they were able to contribute to the knowledge not only in the visual system but also to the characteristics of other sensory system and the brain itself.

The Winners

David H. Hubel was born on the 27th of February 1926 in Windsor, Ontario. He enrolled in Strathcona Academy in Outremont and finished his basic schooling at the age of 18. During his stay there, his main hobbies were chemistry and electronics. He soon got tired of electronics since nothing he built ever worked. He then entered McGill College majoring in mathematics and physics which he finished in 1947.

Despite the lack of knowledge in biology, he applied to a medical school in McGill and was accepted. After graduation, he finished three years of hospital training, two years of residency in neurology which sparked his interest in the nervous system. In 1958, he moved to Wilmer Institute, John Hopkins Hospital to the laboratory of Stephen Kuffler where he started collaborating with Torsten Wiesel. Their collaboration lasted for more than two decades but the fruits of it were unrivalled.

Torsten N. Wiesel was born on the 3rd of June 1924 in Uppsala, Sweden. His father was the chief psychiatrist and head of Beckomberga Hospital and his mother was a housewife. He enrolled at Whitlockska Samskolan, a private school in their city. During his stay there, he was a lazy student who was more interested in sports than studies. At the age of 17, he started focusing more on his studies and did reasonably well in Karolinska Institute medical school, where he received his M.D. in 1954.

In 1955, Wiesel moved to John Hopkins University under Stephen Kuffler. He underwent fellowship in ophthalmology and in 1958, he became an assistant professor in the university. During the same year, David Hubel joined their laboratory and decided to explore the central visual pathway. This marked the beginning of their twenty five years of collaboration.

The Discovery

Hubel and Wiesel worked with cats and rhesus macaque monkeys as their experimental systems. They were able to show that after reaching the retina, the visual stimuli travel the optic nerve and make its way towards the lateral geniculate nucleus or LGN of the thalamus, the first visual processing center of the brain. From the LGN, the visual stimuli travel towards the visual cortex in the occipital lobe of the brain. These structures are the foundations of our current knowledge about the visual system.

Hubel and Wiesel then recorded the electrical impulses of the nerves in the visual cortex [1] in response to various visual stimuli flashed before the eyes. They were able to differentiate two types of cells in the cortex which they named simple and complex. Simple cells respond to only one type of visual stimulus while the complex cells respond to multiple and opposite stimuli.

In another research, Hubel and Wiesel used autoradiography in tracing neuronal connections in the visual system and they found that the visual impulses from the two eyes remain separated in their path from the LGN to the visual cortex.

Furthermore, they found that the impulses then branch out creating a pattern of alternating columns along the grid of cortical cells. The two doctors then called these the ocular dominance columns. They also found that since the cells are arranged in columns, the analysis of the visual impulses takes place in an ordered sequence from one nerve cell to another and every nerve cell is responsible for one particular detail of the image. This means that the analysis and integration of the visual impulses are additive and progressive.

After forming a complete and coherent visual image in the visual cortex, the information is passed on to other parts of the brain to produce emotions and memory that are relevant to the visual image created by the visual cortex.

In their succeeding researches, they were able to show that the cells in the visual cortex have a critical period of development. They found that monocular deprivation in the first six weeks of macaque’s life is sufficient to produce a shift in ocular preference. They also found that an animal with one eye closed for the first three months of life becomes blind in that eye. Their further examinations found no changes in the retina, no changes in the optic tract and LGN; therefore, the changes were in the visual cortex. They also found that visual stimuli are not enough to bring about normal development of the cortex, it was also necessary for the images to have various patterns and contours.

Clinical Implications

Their discovery gave the scientific community a hint about the plasticity of the brain [2] immediately after birth. Their findings also emphasized the role of an enriched environment on the development of the different senses.

Their findings suggest that what we are encountering today and how we perceive the world today depends greatly on our sensory perception during our early years of development. Their findings also lead to the development in the treatment of different childhood eye disorders.

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