Roger Wolcott Sperry (1913–1994) [1]

By: Lienhard, Dina A. Keywords: Chemoaffinity [2] Split-brain [3] Roger Wolcott Sperry [4]

Roger Wolcott Sperry studied the function of the nervous system in the United States during the twentieth century. He studied split-brain patterns in cats and humans [5] that result from separating the two hemispheres of the brain after cutting the corpus callosum [6], the bridge between the two hemispheres of the brain. He found that after separating the corpus callosum [6], the two hemispheres of the brain could not communicate and they performed functions as if the other hemisphere did not exist. Sperry also studied optic nerve regeneration and developed the chemoaffinity hypothesis. The chemoaffinity hypothesis stated that axons, the long fiber-like part of neurons, connect to their target cells through special chemical markers. That challenged the previously accepted resonance principle of neuronal connection. In 1981 Sperry was awarded the Nobel Prize in Physiology or Medicine along with David Hubel and Torsten Wiesel.

Sperry was born on 20 August 1913 in Hartford, Connecticut, to Florence Kraemer Sperry and Francis Bushnell Sperry. He had one younger brother, Russel Loomis. Sperry's father was a banker and his mother was a business student. At the age of eleven, Sperry's father died and his mother became the assistant principal at a high school to financially support the family. During his high school career, Sperry participated in multiple varsity sports. Upon graduating high school, he received a four-year Miller academic scholarship to Oberlin College [7] in Oberlin, Ohio. At Oberlin, Sperry majored in English and participated in athletic activities, graduating in 1935 with a Bachelor of Arts degree. Sperry attended Oberlin College [7] for graduate school as well, where he studied psychology. Sperry received a master's degree in psychology in 1937, after researching brain structure and behavior under Raymond Herbert Stetson, who studied speech, motor, and skill movement.

After graduating from Oberlin with his master's degree, Sperry changed his focus from humanities to science and prepared for a doctoral program in zoology. In 1938 he matriculated at the University of Chicago in Chicago, Illinois, where he worked with Paul Alfred Weiss, who researched neural connections and higher brain functions. While working with Weiss, Sperry studied the surgical interchange of nerves in the hind limbs of rats. In this process, the the main nerve from the right limb was surgically detached and reattached to the left limb, or vice versa. Then Sperry shocked one of the hind limbs with electricity and recorded which limb lifted up in reaction to the stimulus. After repeated experiments, Sperry noticed that the rats never lifted the limb that was being shocked, and instead they lifted the opposite limb where he had attached the motor nerves. For example, whenever the right hind limb was shocked, the left hind limb lifted, and vice versa. That happened was because the right hind limb had the nerve from the left hind limb and the left hind limb had the nerve from the right hind limb. The rats did not lift the correct limb, no matter how many times they were shocked, and they could not learn and adapt to the new position of the motor nerves. Sperry concluded that motor nerve function could not be adapted, and was innate, which meant that the mammal [8] was born with the specified function for each motor nerve and it could not be adjusted.

In 1941, Sperry received a postdoctoral fellowship in Karl Spencer Lashley's laboratory at Harvard University [9] in Cambridge, Massachusetts, where he performed multiple experiments that provided the data for development of the chemoaffinity hypothesis. Just a year later, Sperry followed his mentor Lashley to Orange Park, Florida, to continue their research in an area isolated from World War II. During that time, Sperry studied anurans [10], an order of amphibians [11] including frogs. He performed multiple experiments on the frogs by rotating their eyes and severing the optic nerve, which normally transports the visual information from the retina of the eye to the brain for analysis.

After Sperry's ministrations, the frogs saw the world as upside-down and their sense of right and left reversed. He found that no matter how much time passed by, the frogs were unable to process the visual information normally and their vision was permanently inversed. That meant that the optic nerve fibers grew back to the exact same point of origin as before the surgery and did not adapt to the rotation of the eye. His optic nerve regeneration research in frogs helped Sperry develop his chemoaffinity hypothesis. In 1946, Sperry returned to the University of Chicago [12], where he became an assistant professor. In 1949, Sperry married Norma Gay Deupree. They had two children, a son Glenn Michael in 1953 and a daughter Janeth Hope in 1963.

Almost ten years after his original experiments with frogs in 1951, at the University of Chicago, Sperry proposed a new idea to explain the connectivity of neurons, the chemoaffinity hypothesis. The nervous system consists of two parts, the central nervous system and the peripheral nervous system. The brain and the spinal cord central make up the central nervous system [13] while the peripheral nervous system refers to the nerves that span the entire body.

At the time, scientists maintained that during nervous system development, the axons have a specific frequency recognized by a target cell and adjust for that specific target cell. As a result, the connections between the axons and their target cells were not specific, and any axon could supply any target cell if pushed into its direction. In contrast, Sperry proposed that axons recognized chemical signals produced by their target cells, which specified exactly to what cells the axons could bind. Under Sperry's chemoaffinity hypothesis, each axon within the optic nerve can only bind to its original target cells defined during embryonic development. Therefore, if cut, nerve fibers grow back to their original sites of attachment. The chemoaffinity hypothesis rejected the previously proposed resonance hypothesis that Weiss had introduced, which predicted that the nerve connections made during development were non-specific and random.

Sperry used the chemoaffinity hypothesis to define all connections of the nerves from the brain to their target cells and he stated that axons attach to their target cells through a specified unique chemical marker. Sperry showed that nerve connections were cell-specific and thus once the connections formed between the target cell and the axon during embryonic development, its function and area of attachment could not change. At first, he did not know what guided the specificity of an axon to its target cell, but Sperry hypothesized that it was a simple chemical marker unique to every cell.

Sperry also proposed that the diagram of the nerve connection in the body determined by the genotype and the chemical makers develop during the cellular differentiation [14], which guides axons to their respective targets. Consequently, each axon was predetermined to connect to its target cell alone during development by the genotype, which is the collection of all genes [15] of a mammal [8]. That was a new idea that many researchers studied in depth and eventually the scientific community accepted the theory that chemical connection of axons to their target cells. With his chemoaffinity hypothesis research, Sperry proposed a new understanding of nerve connections inside the human body.

Another area of Sperry's research was the functional specialization of the hemispheres of the brain in mammals. In 1954, Sperry moved to Pasadena, California, where he worked at the California Institute of Technology, or Caltech, in Pasadena, California. At the time, the procedure of cutting the corpus callosum [6], or the bridge between the left and the right hemispheres of the brain, became a treatment option for epilepsy. Epilepsy is a condition that causes random seizures. In that procedure, research physicians would cut the corpus callosum [6] to prevent the electrical impulse for seizures from spreading from one hemisphere to the other. After having this surgery, individuals with epilepsy were able to lead normal lives and perform most tasks without a problem, which caused Sperry to question the function of corpus callosum [6], given that severing it had no apparent effect.

In the 1950s and early 1960s, Sperry originally conducted split-brain research on cats to mimic the brain of an epilepsy patient after surgical intervention. The brain has two hemispheres, each responsible for the opposite side of the body. The right hemisphere controls the left side of the body and the left hemisphere controls the right side of the body. Sperry began his experiments to determine the function of the corpus callosum by cutting the corpus callosum [6] and the optic nerves from both eyes in cats. After the procedure, he taught the cats to distinguish a square from a triangle with their left eye, while the right eye was covered, and distinguish a triangle from a square with their right eye while the left eye was covered. That caused the cats to remember one scenario with one eye and another scenario with the other eye. Later, depending on which eye was covered, the cats could either distinguish a square from a triangle or a triangle from a square. That meant that the cats remembered two different events with two different hemispheres, which functioned as completely separated completely from each other. Since the cats could only distinguish the shapes as two separate scenarios, Sperry concluded that the corpus callosum was crucial in connecting the hemispheres to understand information by the brain. For example, the cats would be able to distinguish the triangle and the square with both eyes with an in-tacked corpus callosum [6].

Given his results in cats, Sperry performed similar tests with human volunteers who had a severed corpus callosum [6] due to outside circumstances. He had similar results. In his human tests, Sperry showed the volunteers words for a short period. If the researcher presented the word to the right field of view, the left hemisphere of the brain processed it and if presented to the left field of view, the right hemisphere of the brain processed it. However, when Sperry asked the volunteers to recall the word that they had just seen, the results from those two simple experiments were very different. No patient could remember the word if they only saw it with their left eye. However, most patients remembered the word if they saw it with their right eye. From those results, Sperry concluded that the left hemisphere is responsible for the right eye and was capable of speech articulation, remembering, and pronouncing words, while the right hemisphere was not able to do that.

In the late 1960s, Sperry performed a follow up experiment to determine how the two hemispheres differed in their function. During the experiment, Sperry asked the volunteers to put their left hand, operated by the right hemisphere of the brain, in a box filled with different objects that they could not see. After that, the patients saw a word that described one of the objects in the box with their left eye only, operated by the right hemisphere. Sperry noted that most patients then picked up that object from the box without seeing it, but if asked for the name of the object, they could not say it and they did not know why they were holding that object. That led Sperry to conclude that the right hemisphere had some language recognition ability, but no speech articulation, which meant that the right hemisphere was able to recognize or read a word, but it could not pronounce that word, so the person would not be able to say it or know what it was.

In the last series of experiments, Sperry showed one object to the right eye of the patients and another object to their left eye. Sperry asked the volunteers to draw what they saw with their left hand only. All the patients drew the object that they saw with their left eye, controlled by the right hemisphere, and described the object that they saw with their right eye, controlled by the left hemisphere. Sperry concluded that each hemispheres of the brain functions independently as the only brain with a severed the corpus callosum, so the hemispheres do not communicate and they can only perform the functions specific to that hemisphere.

Throughout his lifetime, Sperry received thirty-four different awards, including the 1981 Nobel Prize in Physiology or Medicine for his split-brain research in humans [5]. Sperry received the 1972 California Scientists of the Year award, as well as the 1991 Lifetime Award from the American Psychological Association.

Sperry enjoyed ceramics, sculptures, camping, fishing, sports, collecting unusual fossils, and American folk dance. Sperry died on 17 April 1994, in Pasadena, California, from amyotrophic lateral sclerosis, a neurological disease that involves neurons responsible for voluntary muscle movement, which weakens the motor function and muscles.

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principle of neuronal connection. Sperry shared the 1981 Nobel Prize in Physiology or Medicine with David Hubel and Torsten Wiesel.

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