Roger Sperry’s Split Brain Experiments (1959–1968) [1]

By: Lienhard, Dina A. Keywords: Split Brain [2] Chemoaffinity [3] Brain Function [4] Corpus Callosum [5]

In the 1950s and 1960s, Roger Sperry performed experiments on cats, monkeys, andhumans [6] to study functional differences between the two hemispheres of the brain in the United States. To do so he studied the corpus callosum [7], which is a large bundle of neurons that connects the two hemispheres of the brain. Sperry severed the corpus callosum [7] in cats and monkeys to study the function of each side of the brain. He found that if hemispheres were not connected, they functioned independently of one another, which he called a split-brain. The split-brain enabled animals to memorize double the information. Later, Sperry tested the same idea in humans [6] with their corpus callosum [7] severed as treatment for epilepsy, a seizure disorder. He found that the hemispheres in human brains had different functions. The left hemisphere interpreted language but not the right. Sperry shared the Nobel Prize in Physiology or Medicine[8] in 1981for his split-brain research.

Sperry also studied other aspects of brain function and connections in mammals andhumans [6], beyond split-brains, in 1940s and 1950s. In 1963, he developed the chemoaffinity hypothesis, which held that the axons, the long fiber-like process of brain cells, connected to their target organs with special chemical markers. This explained how complex nervous systems could develop from a set of individual nerves. Sperry then also studied brain patterns in frogs, cats, monkeys, and human volunteers. Sperry performed much of his research on the split-brain at California Institute of Technology [9], or Caltech, in Pasadena, California, where he moved in 1954.

Sperry began his research on split-brain in late 1950s to determine the function of thecorpus callosum [7]. He noted that humans [6] with a severed corpus callosum [7] did not show any significant difference in function fromhumans [6] with intact corpus callosum [7], even though their hemispheres could not communicate due to the severing of thecorpus callosum [7]. Sperry postulated that there should be major consequences from cutting the brain structure, as the corpus callosum [7] connected the two hemispheres of the brain, was large, and must have an important function. Sperry began designing experiments to document the effects of a severed corpus callosum [7]. At the time, he knew that each hemisphere of the brain is responsible for movement and vision on the opposite side of the body, so the right hemisphere was responsible for the left eye and vice versa. Therefore, Sperry designed experiments in which he could carefully monitor what each eye saw and therefore what information is was going to each hemisphere.

Sperry experimented with cats, monkeys, and humans [6]. His experiments started with split-brain cats. He closed one of their eyes and presented them with two different blocks, one of which had food under it. After that, he switched the eye patch to the other eye of the cat and put the food under the other block. The cat memorized those events separately and could not distinguish between the blocks with both eyes open. Next, Sperry performed a similar experiment in monkeys, but made them use both eyes at the same time, which was possible due to special projectors and light filters. The split-brain monkeys memorized two mutually exclusive scenarios in the same time a normal monkey memorized one. Sperry concluded that with a severed corpus callosum [7], the hemispheres cannot communicate and each one acts as the only brain.

Sperry moved on to human volunteers who had a severedcorpus callosum [7]. He showed a word to one of the eyes and found that split-brain people could only remember the word they saw with their right eye. Next, Sperry showed the participants two different objects, one to their left eye only and one to their right eye only and then asked them to draw what they saw. All participants drew what they saw with their left eye and described what they saw with their right eye. Sperry concluded that the left hemisphere of the brain could recognize and analyze speech, while the right hemisphere could not.

In the 1960s when Sperry conducted his split-brain research onhumans [6], multiple scientists were studying brain lateralization, the idea that one hemisphere of the brain is better at performing some functions than the other hemisphere. However, researchers did not know which tasks each side of the brain was responsible for, or if each hemisphere acted independently from the other.

Sperry describes his research in cats in the article "Cerebral Organization and Behavior" published in 1961. To test how the cutting of the corpus callosum [7] affected mammals, Sperry cut thecorpus callosum [7] of multiple cats and had them perform some tasks that involved their vision and response to a visual stimulus. After severing each cat´s corpus callosum [7], he covered one of the cat´s eyes to monitor with which eye the cat could see. Sperry could switch the eye patch from one eye to the other, depending on which visual field he wanted the cat to use. Next, Sperry showed the cats two wooden blocks with different designs, a cross and a circle. Sperry put food for the cat under one of the blocks. He taught the cats that when they saw the blocks with one eye, for instance, the right eye, the food was under the circle block, but when they saw it with the left eye, the food was under the block with a cross. Sperry taught the cats to differentiate between those two objects with their paws, pushing the correct wooden block away to get the food.

When Sperry removed the eye patch and the cats could see with both eyes, he performed the same experiment. When the cats could use both eyes, they hesitated and then chose both blocks almost equally. The right eye connects to the left hemisphere and the left eye connects to the right hemispheres. Sperry suspected that since he cut the corpus callosum [7] in those cats, the hemispheres could not communicate. If the hemispheres could not communicate and the information from one eye only went to one hemisphere, then only that hemisphere would remember which block usually had food under it. From that, Sperry concluded that the cats remembered two different scenarios with two different hemispheres. He suspected that the cats technically had two different brains, as their hemispheres could not interact and acted as if the other one did not exist.

Sperry performed a similar experiment with monkeys, in which he also cut theircorpus callosum [7]. He wanted to test if both hemispheres could operate at the same time, even though they were not connected. That required separation of visual fields, or making sure that the right eye saw a circle, while the left eye saw a cross, like in the cat experiment, but without an eye patch and both eyes would see something at the same time instead of interchanging between the open eyes. Sperry solved that by using two projectors that were positioned side-by-side at an angle and showed mutually exclusive images. For example, the projector on the right showed a circle on the left and a cross on the right, while the projector on the left showed a cross on the left and a circle on the right. Sperry placed special light filters in front of each of the monkey´s eyes. The light filters made it so that each eye saw the images from only one of the projectors. That meant one of the eyes saw the circle on the right and the cross on the left, while the other eye saw the cross on the right and the circle on the left. From his experiments with cats, Sperry knew that there was no sharing of information from right and the left hemispheres, so he made the monkeys memorize two different scenarios at the same time.

The left eye saw a scenario where food would be dispersed when the monkey pressed the button corresponding to a cross, while the right eye saw a scenario where food would be dispersed when the monkey pressed a button corresponding to a circle. Ultimately, it was the same button, but the eyes saw it differently because of two projectors and special light filters. Sperry concluded that both hemispheres of the brain were learning two different, reversed, problems at the same time. He noted that the split-brain monkeys learned two problems in the time that it would take a normal monkey to learn one, which supported the assumption that the hemispheres were not communicating and each one was acting as the only brain. That seemed as a benefit of cutting corpus callosum [7], and Sperry questioned whether there were drawbacks to the procedure.

Sperry performed the next set of experiments on human volunteers, who had theircorpus callosum [7] severed previously due to outside factors, such as epilepsy. Sperry asked volunteers to perform multiple tests. From his previous experiments with cats and monkeys, Sperry knew that one, the opposite, hemisphere of the brain would only analyze information from one eye and the hemispheres would not be able to communicate to each other what they saw. He asked the participants to look at a white screen with a black dot in the middle. The black dot was the dividing point for the fields of view for a person, so the right hemisphere of the brain analyzed everything to the left of the dot and the left hemisphere of the brain analyzed everything that appeared to the right of the dot. Next, Sperry showed the participants a word on one side of the black dot for less than a second and asked them to tell him what they saw. When the participants saw the word with their right eye, the left hemisphere of the brain analyzed it and they were able to say what they saw. However, if the participants saw the word with their left eye, processed by right hemisphere, they could not remember what the word was. Sperry concluded that the left hemisphere could recognize and articulate language, while the right one could not.

Sperry then tested the function of the right hemisphere. He asked the participants of the same experiment that could not remember the word because it was in the left visual field to close their eyes and draw the object with their left hand, operated by the right hemisphere, to which he presented the word. Most people could draw the picture of the word they saw and recognize it. Sperry also noted that if he showed the word to the same visual field twice, then the person would recognize it as a word they saw, but if he showed it to the different visual fields, then the participants would not know that they saw the word before. Sperry concluded that the left hemisphere was responsible not only for articulating language, but also for understanding and remembering it, while the right hemisphere could only recognize words, but was not able to articulate them. That supported the previously known idea that the language center was in the left hemisphere.

Sperry performed another similar experiment inhumans [6] to further study the ability of the right hemisphere to recognize words. During that experiment, Sperry asked volunteers to place their left hand into a box with different tools that they could not see. After that, the participants saw a word that described one of the objects in the box in their left field of view only. Sperry noted that most participants then picked up the needed object from the box without seeing it, but if Sperry asked them 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 could 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 his last series of experiments inhumans [6], Sperry showed one object to the right eye of the participants and another object to their left eye. Sperry asked the volunteers to draw what they saw with their left hand only, with closed eyes. All the participants 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. That supported Sperry´s hypothesis that the hemispheres of brain functioned separately as two different brains and did not acknowledge the existence of the other hemisphere, as the description of the object did not match the drawing. Sperry concluded that even though there were no apparent signs of disability in people with a severed corpus callosum [7], the hemispheres did not communicate, so it compromised the full function of the brain.

Sperry received the 1981 Nobel Prize in Physiology or Medicine[8] for his split-brain research. Sperry discovered that the left hemisphere of the brain was responsible for language understanding and articulation, while the right hemisphere could recognize a word, but could not articulate it. Many researchers repeated Sperry´sf experiments to study the split-brain patterns and lateralization of function.

Sources

1. Sperry, Roger W. "Cerebral Organization and Behavior." *Science* 133 (1961): 1749–57. http://people.uncw.edu/puente/sperry/sperrypapers/60s/85-1961.pdf [10] (Access December 8, 2017).
2. Sperry, Roger W. "Hemisphere Deconnection and Unity in Conscious Awareness." *American Psychologist* 28 (1968): 723–33. http://people.uncw.edu/Puente/sperry/sperrypapers/60s/135-1968.pdf [11] (Access December 8, 2017).
3. Sperry, Roger W. "Split-brain Approach to Learning Problems." *In The Neurosciences: A Study Program*, eds. Gardner C. Quarton, Theodore Melnechuk, and Francis O. Schmitt, 714–22. New York: Rockefeller University [12] Press, 1967. ttp://people.uncw.edu/puente/sperry/sperrypapers/60s/130-1967.pdf [13] (Accessed November15, 2017).
4. "The Split Brain Experiments." *Nobelprize.org*. https://www.nobelprize.org/educational/medicine/split-brain/background.html [14] (Accessed May 3, 2017).

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Topic

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Publisher

Arizona State University. School of Life Sciences. Center for Biology and Society. Embryo Project Encyclopedia.

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Last Modified

Monday, September 14, 2020 - 05:14

DC Date Accessioned

Wednesday, December 27, 2017 - 21:30

DC Date Available

Wednesday, December 27, 2017 - 21:30

DC Date Created

2017-12-27

DC Date Created Standard

Wednesday, December 27, 2017 - 05:00

Source URL: https://embryo.asu.edu/pages/roger-sperrys-split-brain-experiments-1959-1968

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