Split-Brain Psychology Essay, Research Paper

Split-Brain Psychology

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Imagine being asked to sing “Mary Had a Little Lamb” and not being able to remember the words but only being able to hum the tune, or knowing the full lyrics, but only being able to bellow out what most closely resembles the cry of an abandoned calf. You cannot sing and remember the words at the same time because your brain hemispheres have been severed from each other. Imagine trying to play the piano, while one hand wants to play Rachmaninov, and the other wants to play major and minor scales. There are countless people suffering through these problems everyday because they underwent a surgical treatment for epilepsy. Although these problems are terribly debilitating to the patients, they have opened a completely new source of boundless information for neurobiologists trying to figure out the effect of the mind on the body, and vice versa. In this paper we will try to present the surgical procedure known as the split-brain operation and its effects on the individuals performance.

In a normal brain, stimuli entering one hemisphere is rapidly communicated by way of the corpus callosum to the other hemisphere, so the brain functions as a unit. When the corpus callosum of an individual is severed, leaving a split brain, the two hemispheres cannot communicate. In some forms of epilepsy a seizure will start in one hemisphere, triggering a massive discharge of neurons through the corpus callosum and into the second hemisphere. In an effort to prevent such massive seizures in severe epileptics, neurosurgeons can surgically sever the corpus callosum, a procedure called a commissurotomy. If one side of the brain can no longer stimulate the other, the likelihood of severe epileptic seizures is greatly reduced.

In a cerebral commissurotomy, the surgeon opens the skull, lays back the brain’s coverings and, with a tool called a cerebral retractor, exposes the corpus callosum between the two hemispheres. The doctor snips through the corpus callosum, severing communication between the hemispheres and preventing the transfer of seizures.

There are two hemispheres in your brain, the right and the left. At first glance, these hemispheres appear to be mirror images of one another, but closer examination reveals that they are highly specialized regions that serve differing functions.

The left hemisphere governs our ability to express ourselves in language. In over 95% of right-handed people, the left hemisphere is dominant for speech. The figure is somewhat lower for left handers, approximately 70%, but still highly significant. The left hemisphere is better then the right at recognizing sequences of words and letters. It controls our logic, our reasoning, and our analytical thought processes. It can focus on details, however it has difficulty comprehending the whole picture.

The perceptual functions of the right hemisphere are more specialized for the analysis of space and geometrical shapes and forms, elements that are all present at the same time (not sequential like language). The right hemisphere is the creative half; it can “see” the whole out of parts, thus allowing us to connect puzzle parts together. The right hemisphere also plays and important role in the comprehension of emotion. In an experiment where subjects were shown pictures of faces with strong facial expression, the right hemisphere was able to discern the expression more accurately then the left hemisphere. In addition, an experiment was done where subjects listened to verbal messages said with different emotions. The messages were presented to each ear separately. When presented to the left hemisphere, the subject was more accurate concerning the verbal content of the message. However, the right hemisphere was more accurate at identifying the emotional tone of the voice.

Ehrenwald has classified important differences between the hemispheres. This information is best expressed as a table:

Table 1: General Left-right hemisphere attributes

Left Right

Thinking Abstract, linear, analytic Concrete, holistic

Cognitive style Rational, logical Intuitive, artistic

Language Rich vocabulary, good grammar and syntax; pose no grammar, syntax; prosody, poor vocabulary metaphoric, verse

Executive capacity Introspection, will, initiative, sense of self, focus on trees Low sense of self, low initiative, focus on forest

Specialized functions Reading, writing, arithmetic, sensory-motor skills; inhibits psi Three i’s, music, rich dream imagery, good face and gestalt recognition, open to psi

Time experience Sequentially ordered, measured “Lived” time, primitive time sense

Spatial orientation Relatively poor Superior, also for shapes, wire figures

Psychoanalytic aspects Secondary process, ego functions, consciousness; superego? Primary process, dream-work, free assoc. hallucinations?

Ideal prototype Aristotle, Appollonian mode, Marx, Freud, Koestler’s Commissar Plato, Dionysian mode, Nietzsche, Jung Koestler’s Yogi

There are two major information pathways by which information of the peripheral nervous system and the central nervous system are exchanged: the somatosensory and the motor control pathways. Some general functions of each system can be separated and described, but these two pathways influence one another in many ways. It is difficult to say, “this is how somatosensory information travels, and this is how motor information travels,” because both information pathways have influences over one another. The following is a very basic summary of the information pathways for both sensory and motor systems. This should provide you with an understanding of how a normal brain communicates with the body, which in turn will help you better understand how a severed corpus callosum might interfere with certain aspects of motor control or visual interpretation.

The somatosenses provide information about what is happening on the surface of our body and inside it. Coetaneous senses, or skin senses, respond to several different stimuli: pressure, vibration, heating, cooling, and events that cause tissue damage (such as pain). Organic senses arise from receptors in and around the internal organs, providing us with unpleasant sensations (such as stomachaches), or pleasurable ones (such as a cold drink on a hot summer day). Receptors located throughout our bodies detect environmental stimuli, and quickly send information to corresponding regions in the brain. All neural information is sent in the same manner, it is where, in the brain, the information is sent which determines how it will be interpreted and what type of corresponding information will be sent back as a response.

Somatosensory axons from the skin, muscles, or internal organs enter the central nervous system via spinal nerves. Somatosensory nerves located in the face and head primarily enter the brain through the cranial nerves.

Precisely localized information (such as fine touch) and imprecisely localized information (such as pain and temperature) are transmitted to the brain by different pathways. Axons that convey precisely localized information ascend throughout the dorsal columns in the white matter of the spinal cord to nuclei in the lower medulla. From there, axons actually cross to the hemisphere opposite the side of the body that the stimuli were received. Axons cross to the opposite side of the brain at the medulla, travel to the thalamus. The thalamus is divided into several nuclei, or groups of neurons of similar shape and function. Some of these nuclei receive the sensory information from the ascending pathways and project it out to the somatosensory cortex so that it can be interpreted.

In contrast, the axons that convey poorly localized information (pain, temperature) enter the spinal cord and immediately cross to the opposite side. From here, these neurons ascend through the spinothalamic tract to the nuclei in the thalamus, subsequently being passed to the correct region of the brain for interpretation.

Information is sent to muscles in the body through motor pathways. This information allows you to flex your biceps, squeeze a tennis ball, correct your posture, and move. There are two types of descending pathways: corticospinal pathways, which originate in the cerebral cortex, and noncorticospinal pathways, which originate in the brainstem. In general, the corticospinal pathways have greater influence over motor neurons that control muscles involved in fine, isolated movements, particularly those of the fingers and hands. The noncortoicospinal pathways are more involved with coordination of the large muscle groups used in things such as the maintenance of upright posture, balance, walking, and in head and body movements when turning toward a specific stimulus. Motor pathways may be excitatory (causing a muscle to contract), or inhibitory (preventing a muscle contraction).

In general, the right hemisphere interprets information and controls actions of the left side of the body. The left hemisphere interprets information and controls actions of the right side of the body. If the connection between the hemispheres is severed, sensory information cannot pass to the correct region of the brain in order for corresponding response to be made. For example, callosal apraxia is a form of limb apraxia caused by damage to the anterior corpus callosum. When a person hears a verbal request to perform a movement, let’s say to raise both hands in the air, circuits in the left hemisphere analyze the meaning of the speech. Then, a neural command activates the region of the brain that contains the memory of the movement, the prefrontal cortex. This information is passed to the part of the brain that controls the actual movement to be performed, the motor cortex. The left motor cortex controls the movements of the right hand, and the right motor cortex controls the movements of the left hand. In order for the right motor cortex to be activated so that the left hand can be raised, the analysis of the verbal command must be passed from the left hemisphere to the right side, through the corpus callosum. Thus, the right arm can perform the requested movement, but the left cannot.

Early after a split brain surgery, the patient shows a marked apraxia of the left hand to verbal command. This occurs because the right hemisphere, which controls the left hand, has poor language comprehension. Remarkably, this symptom recovers to a considerable degree. It is possible that the left hemisphere gains ipsilateral (same side) control of the left hand, and/or the right hemisphere acquires some basic language skill.

Roger Sperry and Ronald Meyers first discovered the split brain in the laboratory in the late 1950’s. Initially they began experimenting with cats, and later proceeded to study monkeys. In 1961 the first human patient was subject to the split brain surgery.

The procedure worked well as a “cure” for patients who suffered from severe epilepsy and did not respond to anti-epileptic drugs. It was soon discovered that patients who had a commissurotomy had some interesting difficulties. Patients were not able to communicate information from one hemisphere to the other, almost as though they now had two separate brains.

In studies of hemispherical differences in visual recognition, stimuli are often presented with a tachistoscope, which flashes an image in a specific part of the visual field so fast that the subject does not have time to move his or her eyes. In a standard split-brain experiment, a split-brain patient is seated in front of a screen that hides his or her hands from view. Behind the screen, there are a couple of objects that the subject cannot see, in this case a deck of cards and a key. The patient focuses their eyes on the center of the screen, and the word “key” is flashed very briefly in the left field of vision. The nonverbal right hemisphere of the brain receives information from the left field of vision, and the person is not able to tell the experimenter what they saw. The patient is then asked to use their left hand to reach behind the screen and pick out the object that corresponds with the word that was flashed. Since the right hemisphere controls movement of the contralateral half of the body, the left hand will be able to correctly identify the object, although the patient is unaware they even saw a word flashed. Further, as long as the object is in the patient’s left hand behind the screen and hidden from view, they cannot relay to the observer what the object is.

Sperry and other scientists proceeded with further experimentation in order to determine the relationship between the right and left hemispheres of the brain. How (and what) the hemispheres communicate would provide valuable insight into the “mind” of a split brain patient. How did a commissurotomy affect one’s perceptions of the outside world?

In one experiment, a word (for example “fork”) was flashed so only the right hemisphere of a patient could receive the information. The patient would not be able to say what the word was. However, if the subject were asked to write what he saw, his left hand would begin to write the word “fork”. If asked what he had written, the patient would have no idea. He would know that he had written something, he could feel his hand going through the motion, yet he could not tell observers what the word was. Because there is no longer a connection between the two hemispheres, information presented to the right half of the brain cannot convey this information to the left. Interestingly enough, the centers for speech interpretation and production are located in the left hemisphere. Similarly, if the patient is blindfolded and a familiar object, such as a toothbrush, is placed in his left hand, he appears to know what it is; for example by making the gesture of brushing his teeth. However, he cannot name the object to the experimenter. If asked what he is doing with the object, gesturing a brushing motion, he has no idea. But if the left hand gives the toothbrush to the right hand, the patient will immediately say “tooth brush”.

Micheal Gazzaniga, who did his graduate work in Sperry’s laboratory, did further experiments which showed the attempts of the left hemisphere to compensate for it’s lack of information, as well as attempts by the right hemisphere to get it’s knowledge conveyed.

When a split brain subject is subjected to tests where the left half of their brain does not know the correct answer, it will often make something up based on the information it does have.

In this particular test, each hemisphere was simultaneously presented with a different cognitive test. Each hemisphere was presented with a picture and told to pick the object that relates to that picture. The left hemisphere was shown a chicken claw, while the right viewed a snow scene. You can see that the patient is pointing to a chicken with his right hand, and a shovel with his left. After each hemisphere responded, the left hemisphere was asked to explain its choices. The way the subject verbally interpreted the double field stimuli is of particular interest. When asked what images he saw on the screen, the patient responded, “I saw a claw and I picked the chicken, and you have to clean out the chicken shed with a shovel.”

Trial after trial, this kind of response occurred. The left hemisphere could easily and accurately identify why the right hand chose the corresponding picture that it had, and then subsequently, and without batting an eye, it would incorporate the right hemisphere’s response into the framework. While observers knew exactly why the right hemisphere and made its choice, the left hemisphere could merely guess. What is interesting is that the left hemisphere did not offer its suggestion in a guessing vein but rather as a statement of fact.

This cartoon illustrates another experiment done with a split brain subject in which the left hemisphere compensates without the person being aware what is going on.

Top Row: The command “Laugh” was flashed to the left field of vision (right hemisphere), and the subject laughed. When asked, “Why are you laughing? the subject said, “Oh…you guys are really something.”

Middle Row: The command “Rub” was flashed to the right hemisphere and the subject’s left hand scratched the back of the right hand. When asked what the command was, the subject said, “Oh…itch.”

Bottom Row: The instructions are “Assume the position of the flashed word.” The word flashed was “Boxer.” The subject clinched both fists and held them in a ready position. “What was the word?” “Oh…boxer.”

The left hemisphere proved extremely adept at immediately attributing cause to the action. The subject could not truly say why they were laughing, for the left hemisphere had not received any information from the right that the command laugh had been flashed. The subject’s left hemisphere evaluated the response and characterized it. It compensated for its lack of knowledge by calling upon previous experiences in which laughing was an appropriate response and said, “Oh…you guys are really something”.

When the patient tried to explain why she was rubbing the back of her right hand, her left hemisphere again tried to compensate for the lack of knowledge, suggesting to her that she had an itch. The fact that she said “itch” instead of “rub” shows that she was guessing. Yet, the patient could be quite accurate when the command gave less leeway for multiple descriptions, as in the case of the word boxer. The test instruction was to “assume the position of….” The subject correctly assumed the pugilistic position, and when asked what the word was, he said, “Boxer.” But on subsequent trials, when she was restrained and the word boxer was flashed, the left hemisphere said it saw nothing. When released, however, she assumed the position and said, “O.K., it was boxer.”

In another experiment, a split brain patient is asked to identify an object – such as a pencil – by reaching inside a bag and feeling it. Success depends on which hand does the reaching. Most of the wiring in the body is arranged contralaterally, with the left hemisphere getting its information from – and controlling – the right side of the body, and vice-versa. Since the left hemisphere normally controls language, when the patient reaches in the bag with his right hand he can readily identify the object. However, if the left hand does the reaching, only the right hemisphere gets the information that the object is a pencil, and is powerless to direct the voice to express this. Occasionally, it seems, a patient’s right hemisphere will hit upon a clever stratagem. By finding the point of a pencil and digging it into his palm, he causes a sharp pain to be sent up the left arm. Some pain fibers are ipsilaterally wired, thus the language-controlling hemisphere gets a clue: it is something sharp enough to cause a pain. “It’s sharp – it’s perhaps a pen? A pencil?” The right hemisphere, overhearing this vocalization, may help it along with some hints – discouraging the pen response, encouraging the pencil – so that by a brief bout of Twenty Questions the left hemisphere is led to the correct answer.

Thus, the right hemisphere may occasionally use other forms of communication in order to compensate for the nonexistent corpus callosum.

These experiments, pioneered by Sperry and colleagues, provided insight into the functionings of the two hemispheres and how they are different.

Until recently it has been believed that the entire corpus callosum must be severed to provide proper relief from the severe epilepsy the surgery was trying to negate. However this is not necessarily the case, the corpus callosum might be able to be severed enough to provide relief, without losing all neural integration.

Dr. H. G. Gordon, a neurobiologist at the California Institute of Technology says the connections at the back of the brain alone are enough to integrate both human hemispheres. Speaking for a California research team, he reported a new form of surgery, devised by P. J. Vogel of Los Angeles, which stops seizures completely, or at least renders them treatable with drugs. At the same time, he added “Psychological tests of Vogel’s patients yield results identical to those of normal subjects. We conclude, the cerebral hemispheres totally integrate if but a small fraction of the corpus callosum remains intact. ”

In Vogel’s new operation (called anterior cerebral commissurotomy) the surgeon opens the skull, lays back the brain’s coverings and, with a tool called a cerebral retractor, exposes the corpus callosum between the two hemispheres

Then he snips through the front three-fourths of the corpus callosum and, while at it, also severs a pipe-cleaner-sized cross connection known as the anterior commissure. But the back of the corpus callosum — the splenium — he leaves intact.

The splenium of the corpus callosum has been found to be the dominant path of the visual aspects of hemispheric integration. Whereas the genus has been found to control motor aspects. For this new procedure, the motor aspects much more pertinent to epilepsy seizures, are severed, while the splenium, the center of visual cross over, remain intact

. This would make the procedure required for severe epilepsy much safer and more practical. The patient would be relieved of the extreme seizures, while retaining interhemisphereic visual pathways and some other communication between hemispheres.

This procedure is now widely used in place of the complete corpus commissurotomy, and experiments are being done with exactly how much of the brain needs commissured. The procedure doesn’t perfectly integrate the two hemispheres, it has been found that callosal transfer times are significantly slower after the operation has occurred. This is thought to be because visual transfer time across the corpus is slower then the motor transfer time. Also bimanual coordination is thought to be somewhat inhibited by this procedure. Never the less, there is definite progress over the complete loss of communication which was thought to happen in the original split brain subjects.

Studying split brain patients’ unusual behaviors has led us to discover valuable information about differences between the two hemispheres. The first of the human split-brain studies began when Michael Gazzaniga joined Roger Sperry as a graduate student at California Tech. In collaboration with neurosurgeon Joseph Bogen, they began a series of commisurotomies. The operation on their first patient, WJ, was a great success. Before the operation he integrated information between the two hemispheres freely, but after the operation he had two separate minds or mental systems, each with its own abilities to learn, remember, and experience emotion and behavior. Yet, WJ, was not completely aware of the changes in his brain. As Gazzaniga put it: “WJ lives happily in Downey, California, with no sense of the enormity of the findings or for that matter any awareness that he had changed.” As previously explained(experiments), words flashed to the right field of vision of patients like WJ could be said and written with the right hand. In contrast, patients couldn’t say or write words flashed to their left field of vision. Although standard experiments revealed that right hemisphere is nonverbal, it is far from incompetent. Even though the right hemisphere could not communicate to observers what stimuli it had been presented with, it did show some verbal comprehension. Even though the patient could not verbalize what word had been presented to the right hemisphere, the left hand was able to point to it within a list.

Another interesting difference between the hemispheres that these patients displayed was that the right hemisphere was distinctly superior in spatial tasks such as arranging blocks and drawing in three dimensions. Researchers showed each hemisphere a simple drawing and had the corresponding hand draw it. Even though all three of the subjects were right-handed, the left-hand drawings were clearly superior.

Because of these hemispheric differences and specializations, split-brain patients have some unusual traits. For example, they are less likely to talk about their feelings, as if they’re unavailable for discussion. The patients give evidence of having two differing minds. The best example of this is patient Paul S. Paul’s right hemisphere developed considerable language ability sometime previous to the operation. Although it is uncommon, occasionally the right hemisphere may share substantial neural circuits with, or even dominate, the left hemisphere’s centers for language comprehension and production. The fact that Paul’s right hemisphere was so well developed in it’s verbal capacity opened a closed door for researchers. For almost all split brain patients, the thoughts and perceptions of the right hemisphere are locked away from expression. Researchers were finally able to interview both hemispheres on their views about friendship, love, hate and aspirations.

Paul’s right hemisphere stated that he wanted to be an automobile racer while his left hemisphere wanted to be a draftsman. Both hemispheres were asked to write whether they liked or disliked a series of items. The study was performed during the Watergate scandal, and one of the items was Richard Nixon. Paul’s right hemisphere expressed “dislike,” while his left expressed “like.” Most split-brain patients would not be able to express the opinions of their right hemispheres as Paul S. did, but this gives us insight on the hidden differences between the hemispheres.

These hidden differences are allowed to demonstrate themselves after a split brain operation because the two hemispheres are closer to existing independently. One hemisphere may not be able to suppress or influence differing opinions, emotions, or desires of the other because most of the communication between the two can no longer occur. As a result, conflicting hemispheric desires or opinions can cause split brain patients to exhibit some strange behaviors. One patient found his left hand struggling against his right hand when trying to pull up his pants in the morning. While the right hand tried to pull them up, the left was trying to pull them down. On another occasion, he was angry with his wife and attacked her with his left hand while simultaneously trying to protect her with his right!

Split-brain patients have also taught us about dreaming. Scientists had hypothesized that dreaming is a right hemisphere activity, but they found that split brain patients do report dreaming. They found, therefore, that the left hemisphere must have some access to dream material. What was most interesting was the actual content of the dreams of the split-brain patients. Klaus Hoppe, a psychoanalyst, analyzed the dreams of twelve patients. He found that the dreams were not like the dreams of most normal people. ” The content of the dreams reflected reality, affect, and drives. Even in the more elaborate dream, there was a remarkable lack of distortion of latent dream thoughts. The findings show that the left hemisphere alone is able to produce dreams. Patients, after commisurotomy, reveal a paucity of dreams, fantasies, and symbols. Their dreams lack the characteristics of dream work; their fantasies are unimaginative, utilitarian, and tied to reality; their symbolization is concretistic, discursive, and rigid.”

These studies of abnormalities of split brain patients as opposed to normal people are providing much insight on hemispheric specialization. Even if some people cannot play the piano correctly, put on a pair of pants, or even comb their hair properly, they can achieve a certain amount of normalcy in their lives by controlling the seizures that affected them previously. They can as well gain some comfort in the knowledge that their ailments are helping psychobiologists learn more about the brain and its functions than ever before.