Running head: SPLIT-BRAIN PATIENTS

Discovering the Unique Individuals Behind Split-Brain Patient Anonymity

Ashley D. Eldridge

University of North Carolina at Wilmington

Abstract

The present writer sought to explore the case histories of Roger Sperry's split-brain patients in detail. All patients opted to undergo the cerebral commissurotomy at White Memorial Medical Center in Los Angeles, California, as a last resort to combat their medically unresponsive epilepsy. Researchers' hypotheses were strengthened when 10 of patients experienced major improvement in their epilepsy (Benson & Zaidel, 1985; Sperry, 1966). The majority of patients were educated, at least attending high school (Perception of Bilateral, Levy, Trevarthen & Sperry, 1972). The patients with the fastest recoveries and the least surgical complications participated in the most postoperative experiments (*Dyspraxia*, Gazzaniga, Bogen, Sperry, 1967). Patients may have also been chosen for particular experiments based on their availability and ability to perform tasks that comprised the tests. Most likely, this selection of participants produced a lack of information available on particular patients due to their limited participation in studies.

Discovering the Unique Individuals Behind Split-brain Patient Anonymity

The brain is an extremely complex organ, whose functions are controlled by electrical impulses in its neural pathways (Scofield & Reay, 2000). A myriad of synapses in these neural pathways work together, producing countless possible combinations of interactions. The functions of the brain define what it is to be human, allowing us to think and behave in an intelligent way. The brain controls how an individual's body moves and sustains itself, and how he or she thinks and feels. Without the brain mankind would not exist (Scofield & Reay, 2000).

Scientists know a lot about the way the brain functions today, having discovered that cells in the brain communicate, sending billions of signals in a very short period of time (Scofield & Reay, 2000). The lines of communication in the brain meet in a large neural exchange called the corpus callosum. Half a century ago no one new its true purpose, thinking that it only held the two halves of brain together. Because it occupies a huge space in the brain compared to the other sections of the organ and is so complex, scientists began to search for a more important possible function (Scofield & Reay, 2000).

Two scientists began to investigate this question at the same time, unaware of each other's work (Scofield & Reay, 2000). Roger Sperry of the California Institute of Technology was studying the corpus callosum, believing it that it played the key role in the brain's communication system. During the 1950's he began a series of revolutionary experiments, surgically severing the corpus callosum of cats and monkeys. He hypothesized that movement, balance, or sleep patterns would be affected by the operation (Scofield & Reay, 2000).

With the animals apparently unaffected, the results seemed to show that the corpus callosum only served to hold the two hemispheres of the brain together, but it later became

evident that the two sides of the monkeys' brains could no longer coordinate the two sides of their bodies (Scofield & Reay, 2000). In the normal brain, the right side controls the body's left side and the left side controls the body's right side. When a signal was shown to one eye, the monkeys could not respond correctly by taking the food reward with their opposite hand, because the opposite hand does not recognize the signal when the two sides of the brain lack a pathway to communicate. Sperry proved through this experiment that the corpus callosum was somehow enabling the two hemispheres to interact (Scofield & Reay, 2000).

Sperry did not learn how this occurred until he met Joe Bogen, a neurosurgeon who had just completed his surgical training (Scofield & Reay, 2000). Bogen treated severely epileptic patients, and he wanted to find a way to improve their quality of life. A seizure occurs when many neurons in the brain fire simultaneously, often recruiting other cells into this synchrony of firing. In normal brain wave functioning, neurons fire separately, triggering the adjacent neuron to fire. Bogen calls this a "mosaic" of firing (Scofield & Reay, 2000).

When the synchrony spreads to both sides of the brain, a generalized seizure occurs (Scofield & Reay, 2000). During this type of seizure people often make noise, fall down, and convulse. Another term for a generalized seizure is a grand mal seizure. Bogen knew that seizures begin in small parts of the brain and then radiate through the rest of the brain, and he wanted to know if the dispersion could be stopped (Scofield & Reay, 2000).

At age 29 he developed the theory that if the corpus callosum was cut, the seizure could not spread across the brain (Scofield & Reay, 2000). He believed that it would prevent a grand mal seizure and prevent more harm, like the injury that a fall during the seizure might cause. The procedure would have high risks, but he had studied Sperry and was convinced that it would

be effective because the monkeys in Sperry's study were still capable of doing complex psychological experiments after their operations (Scofield & Reay, 2000).

The surgery seemed fairly safe, and so beginning on February 1962, after 10 months of planning, the first of 10 patients, subsequently dubbed the "California series," underwent the surgery (Scofield & Reay, 2000). It was a bold and radical experiment. Several other surgeons including, Phillip Vogel, worked with the two men on the study. The surgery involved opening the skull, retracting one side of brain and then cutting the connection between the two massive hemispheres. The corpus callosum is made up of 200 million nerve fibers. A procedure this bold could only be used as a last resort by neurosurgeons in the treatment of severe epilepsy. The patients were willing to take the risk to escape a life of relentless seizures (Scofield & Reay, 2000).

Bogen knew that the results would be complex, so he had planned in advance to evaluate the patients before and after the operation, maximizing the scientific information that could be obtained from the study (Scofield & Reay, 2000). He approached Sperry to do this job during the planning stages. Sperry assembled a team to work on the project. His main objective of the testing was to research whether or not any psychological side effects resulted from the operation. As a result of the surgery, 9 out of 10 patients had an impressive decline in the frequency and intensity of their seizures, due to the prevention of seizure dispersion across the hemispheres of the brain (Scofield & Reay, 2000).

The identities of the split-brain patients were concealed during Bogen, Vogel and Sperry's studies in an effort to protect the patients and their families. The patients are referred to in articles by their first names, first name and last initial, first and last initial, or by their case numbers, since each patient was an individual case study. Very little is known about these

patients, probably because it is so difficult to trace them over the progression of postoperative studies. They were referred to in a completely different way by the authors in each scientific article, using one of the techniques mentioned previously and usually stating their ages and occupations at the time each study was conducted. These inconsistencies in style of case history make it very difficult to learn much about the patients' lives, evident in the different interpretations of case facts (e.g. in the various scientific articles). For example, the success of the operation and the recovery of each patient are reported differently across some of the articles. The present writer could not locate a list of the 10 specific patients who made up the "California series," and the opinions on the total number of patients studied differed across sources, as did the individual patients listed. An attempt will be made in the subsequent discussion to reveal more about this diverse group of fascinating individuals who lived postoperative lives of dual consciousness.

Method

Over 260 scientific articles, 5 books, and 2 videotapes were researched in the process of compiling data on the split-brain patients. Of these sources, only 32 of the articles, 2 books and 2 videos pertained to the specific topic chosen by the present writer. Only 24 articles, 1 book, and 1 video were cited in the text or in figures (see Appendix), however. These final sources were chosen because they specifically pertained to patient case histories. A working list of patients, including their characteristics and case histories, was developed as the sources were reviewed. A large portion of the review process consisted of attempts at piecing together the puzzle of each patient, made obscure by the variety of techniques authors used to identify individual patients. The information discovered about each patient will be presented in the discussion to follow.

The Split-brain Patients

Patients of Bogen and Vogel

?*K. S.*

This patient may or may not be the individual, Katie, featured in The Learning Channel production of "Alien Hand" (Scofield & Reay, 2000), depicted as unable to point to an answer with her right hand without her left hand fighting the choice. K. S. was a 20-year-old sophomore at Los Angeles City College. She never developed a corpus callosum; this was discovered unexpectedly during her hospitalization at Los Angeles County General Hospital when cranial X-rays were taken to determine the cause of her blackouts and headaches (Sperry, 1968). Doctors determined that the cause was an advanced case of hydrocephalus. Before this hospitalization, both K. S. and her family perceived her to be perfectly normal (Sperry, 1968).

She underwent brain surgery to treat the hydrocephalus and recovered, returning to college (Sperry, 1968). She made average grades of B's and C's, but had difficulty with geometry (Sperry, 1968; Franco & Sperry, 1977). She also worked 20 hours per week as an office clerk for Los Angeles City College (Sperry, 1968). Her availability to participate in experiments made her a prime candidate for future testing (Sperry, 1968).

Researchers administered the WAIS Intelligence Test to her 2 months after her brain surgery (Sperry, 1968). Both her I.Q. (see Table 2) and grades reflected an "average, or slightly above average mental achievement," an ability uncommon in other split-brain patients, but not exclusive (Sperry, 1968). She also had no trouble with any of the other tests (see figures) unlike the patients who participated in the surgery (Sperry, 1976). Her results reflected the way control subjects should perform on the tests. Researchers hypothesized that these results were due to a life-long adaptation process she had developed to deal with the separate hemispheres and to the availability of the undamaged "anterior commissure" section of her brain for compensation (Sperry, 1976).

Researchers also believed that "minor hemisphere lateralization" of K. S.'s brain had taken place due to "developmental interference within the right-hemsiphere," assumed to have occurred as a result of the presence of language and speech centers in both hemispheres (Franco & Sperry, 1977). Evidence for this presence of language centers in both sides of her brain was discovered through "lateral amytal" tests (Sperry, 1976). Sperry believed that her ability to function normally despite the absence of a corpus callosum supported his theory that the brain was plastic and could adapt to cope with structural abnormalities (Sperry, 1976).

?*Walter or W. J.*

W. J. was the first patient in the world to have his corpus callosum severed and the two sides of his brain separated (Macalester, 2002; Sperry, 1966). W. J. suffered convulsions from grand mal seizures for fifteen years following a trauma to the brain at age 30, a shrapnel war injury that occurred in 1944 during WWII (Scofield & Reay, 2002; Gazzaniga, Bogen, Sperry, 1962, 1965). His parachute failed to open fully while executing a jump over Holland during a bombing raid (Bogen & Vogel, 1962). He suffered a broken leg and was knocked unconscious, possibly remaining so for 48 hours. He was discovered and brought to a prison camp where he was again knocked unconscious with a riffle butt by a guard, further damaging the left parietal region of his brain. Brain hemorrhaging probably continued for several weeks after the parachute jump. He lost around 100 lb while at the prison camp, literally starving and showing signs of malnutrition. After his release from the prison camp his "paresthsias, dystrophic skin changes in both hands and widespread, moderate muscular atrophy were studied by electrogram," finding a "peripheral polyneuropathy" that may have been the result of "severe avitaminosis" (Bogen & Vogel, 1962).

He found a job as a payroll clerk after returning home from war, but soon began blacking-out for unknown periods of time (Bogen & Vogel, 1962). After these blackouts he would not remember what he had done, where he had been, how he had gotten there, or when he had lost consciousness. Following one of these episodes he regained consciousness, realizing that he had driven 50 miles away from home with no recollection of the experience. The blackout spells were frequent, and W. J. suffered with them for 12 years before seeking treatment at White Memorial Hospital in 1956 (Bogen & Vogel, 1962).

His convulsive seizures had begun earlier (Bogen & Vogel, 1962). He endured his first "frank" or generalized convulsion at age 37 when he was hospitalized in 1951 for urgent

"laparotomy" surgery to remove the blockage in his intestines, which resulted from an earlier appendectomy that developed peritonitis (Bogen & Vogel, 1962). His convulsive episodes became more serious over time and occurred more often, culminating in an epileptic state at least once every 3 to 4 months. One of the worst of these episodes occurred in 1953 when an intense series of convulsions continued for many days, leaving his left side numb. He recovered quickly from the episode, but he never regained complete feeling in his left side (Bogen & Vogel, 1962).

In 1956 when W. J., then age 42, first sought treatment at White Memorial Hospital for the convulsions, they were occurring at least two or three times per day (Bogen & Vogel, 1962). In this same year he also experienced a massive epileptic episode, enduring nearly a week of constant seizures. "A mild myocardial infarction" may have occurred during the episode (Bogen & Vogel, 1962). He was heavily medicated, beginning in 1957, and was hospitalized many times in an attempt to lessen the severity of his epilepsy (Bogen & Vogel, 1962). He was even treated at the Bethesda National Institutes of Health (Sperry, 1968).

However, the seizures did not respond to medication and treatment (Bogen & Vogel, 1962). The frequency of seizures was the lowest while taking Mysoline 250-mg q.i.d., phenobarbital 30-mg q.i.d., Diamox 250-mg q.i.d., Thorazine 25-mg q.i.d, and Zarotonin 250-mg q.i.d, equaling about 1 per week, and the was the highest while taking Dilantin, phenobarbital and Tridione, equaling 7 to 10 per day and culminating in "status epilepticus" every 2 to 3 months (Bogen & Vogel, 1962; Gazzaniga et al., 1962). The beginning of an episode often co-occurred with emotional disturbances, especially with hysterical behavior (Bogen & Vogel, 1962). He claimed that before these convulsions he was overcome by a dizzy feeling similar to the sensation of "'a Ferris wheel revolving'" (Bogen & Vogel, 1962). Also, facial contortions and outbursts like "'Bail out, Jerry!'" sometimes accompanied the onset of an attack (Bogen &

Vogel, 1962). His head usually turned to the left during the convulsions and "they typically culminated in apnea, cyanosis, and severe clonics which were most frequent in the right arm and leg" (Bogen & Vogel, 1962). The most severe convulsions could only be stopped by administering "ether anesthesia" and "on one occasion 18 grains of phenobarbital given intravenously over a 10 minute period" (Bogen & Vogel, 1962).

W. J. had suffered many head injuries involving his face or scalp from falls during the seizures, and one fall into a fire resulted in burns, but incontinence and tongue-biting did not occur very often (Bogen & Vogel, 1962). W. J. took 50-mg Dramamine every 4 hours to ease the "mild ataxia and severe vertigo" that he experienced with his convulsions, a potential effect of the "traumatic labyrinthitis" (Bogen& Vogel, 1962). He also suffered from other medical conditions in addition to the seizures, taking medication for a "bleeding peptic ulcer," "occasional angina pectoris," a "recurrent urine infection," and "diabetes insipidus" (Bogen & Vogel, 1962). He was allergic to "peanut oil, morphine (but not codeine), and several radio-opaque iodine compounds" (Bogen & Vogel, 1962). He was also almost always below a healthy bodyweight and showed signs of normotension (Bogen & Vogel, 1962).

Both hemispheres of his brain interacted normally before the operation (Macalester, 2002). His sensory and motor functions were also normal aside from a slight hypesthesia, or jerkiness of movement on his left side (Gazzaniga et al., 1962, 1965). He could also correctly recognize and comprehend visual stimuli in both halves of his visual field and record the stimuli with both hands (Gazzaniga et al., 1965).

W. J. had been a very intelligent (see Table 2) and promising young man before his war injury. He had only earned a high school diploma, but was highly self-educated (Gazzaniga et al. 1962, 1965). He was also a well-liked patient; Gazzaniga (2002) described him as a

"charming, take-charge" type of person. Until his seizures escalated he read avidly, especially Greek history and the works of Victor Hugo (Gazzaniga et al., 1962, 1965). Unable to focus on little more than a newspaper headline, the seizures impaired his reading ability so much that he was forced to resort to watching TV (Gazzaniga et al., 1965). By 1962 both he and his family could no longer cope with the effects of epilepsy on his health and life-quality.

The operation took place on February 4, 1962, his 12th admission to White Memorial Hospital (Bogen & Vogel, 1962). During the operation the surgeons determined that no massa intermedia had developed in his brain and that some atrophy had occurred in the part of the right frontal lobe exposed in the procedure (Gazzaniga et al., 1962). The operation was a great success with no generalized convulsions occurring in the 30 months following (Gazzaniga et al., 1962).

According to Gazzaniga and colleagues (1962), "Generalized weakness, akinesis, and mutism, were evident immediately after the surgery but had cleared up when post-operative testing started." Just after the operation, he experienced acute "hemiplegia" on his left side and strikingly "hyperactive reflexes on the right side" (Gazzaniga et al., 1962). He could not easily "cooperate with requests," talk, feed himself, or initiate any movement by himself for about a week after the procedure (Bogen & Vogel, 1962).

Walter began taking anticonvulsant medications again a few days following the surgery (Bogen & Vogel, 1962). Before the readminstration of the drugs, frequent but short convulsions of 1 to 4 min occurred on his right side while he was still conscious. During the time between resumption of medication and post-operative testing, he experienced only three brief seizure episodes accompanied by loss of consciousness but no major convulsions (Bogen & Vogel,

1962). Also in this period after the surgery he experienced "occasional brief episodes of clonic-like tremor confined to the distal portion of the right arm or leg" (Gazzaniga et al., 1962).

A month after the operation he was almost fully recovered, "with the only neurologic symptoms … being a sensory deficit and persistent tonic grasp reflex to the left" (Bogen & Vogel, 1962). He also finally began to talk again a month following the surgery (Pietsch, 2002). This short-term aphasia was not very common with the other patients (Pietsch, 2002). Within 4 months post-operative he could walk on his own and perform complicated tasks with both hands without difficulty, such as lighting a cigarette. Even 5 ½ years after the operation W. J. claimed not to have experienced a single generalized convulsive episode (Sperry, 1968).

The procedure did not seem to affect his I. Q. (see Table 2) significantly or his personality, which remained cheerful and witty (Gazzaniga et al., 1965). The only lasting neurological side effects were a "left symbolic hemianopia, eupraxic anomia and agraphia in the left hand," with a difficulty in controlling the movements of this hand (Bogen & Vogel, 1962). He was annoyed at the inability of his hands to work together, at times even combating each other (Sperry, 1966). W. J. suffered from what Bogen would later dub "alien hand," a condition in which the patient's left hand assumed a life of its own, performing complex tasks without the patient being able to control it (Bogen & Vogel, 1962; Scofield & Reay, 2000). The surgery did not affect his vision, however, and he performed well on the "Ishihara colour" card task (Gazzaniga et al., 1965). Over time the dosage of his medication was lowered, as his epilepsy subsided, and an "overall improvement in his behavior and well-being" was noted (Sperry, 1968).

After the surgery, W. J. had two different minds or consciousnesses that learned, remembered, felt, and behaved differently (Macalester, 2002). He went on to live a normal life

in Downey, California, however, without realizing the extraordinary implications of the study or the fact that he had changed dramatically following the operation. Walter J. is probably the best-known split-brain patient because he was the first to undergo the groundbreaking surgery and because the success of his operation made him the one of the best candidates to participate in the majority of the post-operative studies (Macalester, 2002).

?*N. G.*

N. G. was a 32-year-old housewife who chose to undergo the operation as a last resort to treat her advanced epilepsy (Levy and Sperry, 1970). She was born premature in the 6th month of pregnancy on June 29, 1933, weighing only 5 lb, and was kept in an incubator for many weeks (Sperry, Gazzaniga & Bogen, 1969; Bogen, Fisher & Vogel, 1965). Her mother was only 22-years-old and already had another 3-year-old daughter (Bogen et al., 1965).

N. G. was a healthy baby, except for the fact that she was not growing very fast (Bogen et al., 1965). Her parents brought her to White Memorial Hospital for the first time when she was only 3-months-old, concerned that she only weighed 7 lb 8 oz and was only 19 inches long (Bogen et al., 1965). Her development from 3 months on seemed normal (Sperry et al., 1969). She had learned to walk by age 1 and to talk by age 2, as do most children (Bogen et al., 1965).

Something in her development could have gone wrong, but it was not until years later when she suffered her first generalized, convulsive seizure. A recent high school graduate, she was 18 and 4 months pregnant at the time; a miscarriage resulted from the trauma (Sperry et al., 1969; Trevarthen & Sperry, 1973; Bogen, Fisher & Vogel, 1965). Doctors believed that the seizure began in the temporal lobe (Levy, Trevarthen & Sperry, 1972). Her blood pressure at the time had risen to 170/110 mm Hg, and even when it decreased to a healthy level, her seizures did not subside (Bogen et al., 1965). Twelve years later, researchers found a genetic link,

discovering that both her daughter and grandmother were epileptic (Trevarthen & Sperry, 1973; Bogen et al., 1965).

She was urged by her husband to seek medical attention again after suffering her 8th known convulsion in 1952 (Bogen et al., 1965). He had observed all eight episodes, being awakened at night by peculiar noises coming from his wife, and finding her "'stiffened out'" in bed for a 2 to 3 min interval (Bogen et al., 1965). "When she was admitted to the hospital for examination" on April 6, 1952, "an EEG and a X-ray revealed a calcification 1 cm in diameter beneath the right central cortex" that was about the size of a "mulberry" (Levy & Sperry, 1970). Doctors also discovered a calcification "near the right hilum," using a chest x-ray, and a "2 cm calcification in the central part of the Rolandic fissure" (Bogen et al., 1965; Levy et al., 1972). The cause of the seizures was not discovered, but the presence of the calcifications in the brain, many irregular EEG's indicating abnormality in the left temporal region, and "hypaesthesia to pinprick in the left hand shortly after a seizure" suggested brain damage even before the commissurotomy was to take place (Sperry et al., 1969; Bogen et al., 1965).

She continued to feel peculiar sensations in the left side of her body just before her convulsions, which progressed into generalized, convulsive seizures (Trevarthen & Sperry, 1973). Her seizures were becoming more frequent by 1959, when she experienced her first seizure during the day (Bogen et al., 1965). Doctors tried unsuccessfully to lessen the severity of her seizures through a routine of 2.5-mg of diphenylhydantoin, phenobarbital, and methamphetamine hydrochloride, in the form of Phelantin Kapseals, twice a day. N. G. continued to experience episodes where she would gaze vacantly ahead, run through her home without purpose, have generalized convulsive seizures, or experience loss of bladder or bowel control and bite her tongue during attacks (Bogen et al., 1965).

Her epilepsy escalated through August of 1963, even though 250-mg of ethosuximide, or Zarotonin, and 500-mg of phensuximide, or Milontin, had been added to her twice daily medication routine (Bogen et al., 1965). She was hospitalized three times between 1959 and 1963 for her epilepsy. N. G. and her family were convinced that the operation was the only option left. Following an ordeal of 50 epileptic episodes in 3 days while heavily medicated with 250-mg. of primidone, or Mysoline, twice daily, 250-mg. of Zarotonin twice daily, and 1-grain of phenobarbital four times per day, she finally agreed to undergo the operation at age 30 on September 5, 1963 (Bogen et al., 1965).

The surgery went fairly well, with doctors discovering that her brain "looked and felt normal," but they were forced to cut through a "fairly large vein draining the right parietal area into the sagittal sinus" (Bogen et al., 1965). Fortunately, no major bleeding occurred (Bogen et al., 1965). Her recovery was quick and uneventful, being able to grip an object with her right hand within only 4 hours of the operation. Her reflexes on the right side of her body were encouraging the day of the operation, but her left side remained limp, except for an instance where she was able to use both hands to pull the bed sheet and blanket over herself (Bogen et al., 1965).

She could produce "intelligible speech" 2 days after the operation and recognize individuals and places by day 3 (Sperry et al., 1969). She could also talk on the telephone by day 3 (Gazzaniga & Sperry, 1967). By the 4th day after the operation, she also regained memory of her husband and strangers she had met for only a short time 2 days prior to the surgery (Sperry, 1968). She had her first seizure after the operation on day 6 while medicated every 6 hours with 100-mg of diphenylhydantoin, or Dilantin, and 30-mg of Phenobarbital, experiencing "clonic spasms of the right side of the face and the right arm and leg which lasted for 30 seconds"

(Bogen et al., 1965). She had begun to experience odd sensations in the left half of her body just before going into convulsions (Bogen et al., 1965).

A few temporary complications from the operation occurred during the first week including: paralysis of the left side of her body on the day of the operation, memory loss and speech irregularities (Trevarthen & Sperry, 1973; Bogen et al., 1965). She could, however, hum some of her "old favorite" songs with "good tonal quality" throughout this week, and walk independently and feed herself by the end of the week (Sperry, 1968; Gazzaniga & Sperry, 1967). Curiously, for the first 2 weeks, her mood and delivery of speech would suddenly change dramatically during a conversation, speaking normally one minute and then acting very upset the next without losing her thought pattern (Gazzaniga & Sperry, 1967). She would often alternate between two different moods without stopping her speech or losing the sense of what she was saying, participating normally in the conversation (Gazzaniga & Sperry, 1967).

She could not tell time or remember recent events for a few weeks (Sperry, 1967). Also, by the 3rd week she was still not able to move her hand voluntarily to comply with commands given by experimenters, but she could easily move her fingers to imitate hand gestures modeled by experimenters (see figures) (Bogen et al., 1965). The instances of "right-sided clonic spasms" began to occur more often, and a few episodes of blank starring that lasted for a few minutes took place between day 20 and day 25 when doctors attempted to reduce anticonvulsant medications (Bogen et al., 1965). On day 33 she had her first generalized convulsion following the operation. She was walking independently by the 4th week. When another generalized convulsion occurred on day 40, doctors reinstated a routine of anticonvulsants. She was not able to voluntarily comply with tasks with her left hand until 8 months after the operation (Bogen et al., 1965).

She would often become very chatty during interviews with experimenters, especially when she became tired (Bogen et al., 1965). Researchers believed that many of her symptoms were due to the fact that "part or all of her right fornix had been divided" during the operation (Gazzaniga & Sperry, 1967). She was able to remember events before her surgery very well, including being in the hospital before the procedure. Her family did complain, however, that her memory was poor for the first 4 months after the operation (Gazzaniga & Sperry, 1967).

Her post-operative EEG readings were normal (Trevarthen & Sperry, 1973). She could use both hands well, but occasionally they would not work together on the same task or would combat each other with each seeming to have a will of its own (Trevarthen & Sperry, 1973; Sperry, 1966). These were signs of alien hand syndrome. Her right eye was dominant, and she did not have a very good sense of direction, turning to the right if given a choice of direction (Trevarthen & Sperry, 1973).

The difference in her verbal and performance WAIS IQ scores implied that she had minor hemisphere damage (Sperry et al., 1969). Her poor performance on the block design subtest provided further evidence for this kind of brain damage. She could not perform well on tests with either hand, nor could she perform well using both hands (Sperry et al., 1969). More tests were conducted, discovering that she showed "normal sensitivity for two-point discriminations on both the left and right sides of [her] body" (Milner, 1967).

Her generalized convulsions after the operation were brought under control by anticonvulsants (Sperry, 1968). N. G. had not experienced another convulsion since day 40 of her recovery when she was examined again in 1965, 2 years after the operation (Bogen et al., 1965). These medications were reduced over time, with N. G. experiencing no generalized convulsions within 4 years of the operation, and her seizures nearly disappeared within 7 years

(Sperry, 1968; Trevarthen & Sperry, 1973). She was still being postoperatively tested in 1972 (Zaidel & Sperry, 1976).

The operation was successful in reducing and controlling the proliferation and intensity of her seizures (Sperry, 1968). She went on to live a relatively normal life, appearing at first glance little different from other people around her. The success of her operation was so great that she was able to resume her full role as a wife and mother within a year after the surgery (Sperry et al., 1969).

?*A. A.*

According to Trevarthen and Sperry (1973), A. A. "was delivered by forceps" 14 hours after labor was induced "because of toxaemia" (Nebes & Sperry, 1971). Complications with labor and birth were most likely due to the fact that it was his mother's first pregnancy (Nebes & Sperry, 1971). He had limited use of his right arm (but see Table 1), due to a brain injury at birth, causing damage in the "frontoparietal area in a region extending dorsal from the Sylvian fissure in the left hemisphere" (Levy, Trevarthen & Sperry, 1972).

Fever and convulsive seizures and began as early as 4 months of age (Trevarthen & Sperry, 1973). His development and growth from then on appeared to be normal (Nebes & Sperry, 1971). At age 5, however, his condition took a turn for the worse, developing generalized convulsions that often began as "'spasms' or 'drawing up'" in the right arm (Nebes & Sperry, 1971), and persisted with age (Trevarthen & Sperry, 1973). The seizures often left him with a lack of sensation in the right hand (Levy et al., 1972). An EEG revealed irregularities concentrated in the left hemisphere of the brain (Nebes & Sperry, 1971).

By the time that he reached the fourth grade, he had begun failing in all of his schoolwork (Nebes & Sperry, 1971). At this time the seizures had become more intense, and continued to do

so for the next 8 years, even with rigorous attempts at medicinal intervention. His injuries from falls also became progressively more serious, including a "fractured clavicle" and "a number of head injuries" (Nebes & Sperry, 1971).

By the age of 14, A. A. and his family agreed that he should have the surgery as a last resort, so he underwent the operation on October 14, 1964, resulting in many complications (Nebes & Sperry, 1971). The massa intermedia could not be found in his brain during the surgery (Nebes & Sperry, 1971). He also experienced "right cerebral swelling" in response to the necessary cutting of two large veins between the two hemispheres, which in turn caused "a mildly spastic left leg with a positive Babinski sign" (Nebes & Sperry, 1971). The "odema and intracranial pressure" that occurred during his recuperation probably caused damage to the frontal lobe in the right hemisphere of his brain, producing dragging of the left leg when he walked (Levy et al., 1972). His left arm, however, was not impaired (Trevarthen & Sperry, 1973).

Before the operation he spoke slowly and could use both hands almost ambidextrously (Trevarthen & Sperry, 1973). The sensitivity in his right arm decreased after the operation, sometimes accompanied by numbness, loss of coordination, and loss of speech (Trevarthen & Sperry, 1973). His slowness of speech persisted after the operation, and he had great difficulty with verbal or computation tasks (Levy et al., 1972).

Two years after the operation simple tactile tests were administered to A. A., finding that he had a slight difficulty discriminating where on his right hand a touch or sensation of pressure occurred and in picking a specific object from a group of objects when in a blind condition (see figures) (Nebes & Sperry, 1971). He was 19-years-old when more post-operative tests were conducted (Trevarthen & Sperry, 1973). He had been attending a city college with a special

school for the handicapped ever since 1966 (Trevarthen & Sperry, 1973; Levy et al., 1972, Nebes & Sperry, 1971). His speech continued to be slow after the operation, and his intellectual abilities suffered (Trevarthen & Sperry, 1973). "He show[ed] a slight attentional bias favoring the left eye" (Trevarthen & Sperry, 1973). He was still being postoperatively tested in 1972 (Zaidel & Sperry, 1976).

?*Larry or L. B.*

L. B. was born by cesarean section on May 15, 1952. He was the third child in the family to be delivered by such means (Sperry et al., 1969). His birth weight was somewhat low, equaling 5 lb, and due to his "cyanotic" condition, he was kept in an "Isolette for eight days" after his birth. His development as an infant, however, was healthy and normal. He was full of life and energy, learning to sit up at 5 months and to do so by himself at 7 months. By 18 months he had learned to walk on his own, had gained 10 lb, and could talk (Sperry et al., 1969).

L. B. began to develop a history of convulsive seizures at age 3, though, probably resulting from brain injuries suffered during birth (Levy & Sperry, 1970). Doctors failed in attempts to alleviate his seizures with medication, as they occurred more often and became more serious over time (Sperry et al., 1969). By 1965, L. B. and his family finally decided to have the surgery after a year in which he suffered over 50 generalized convulsions, while maintaining a rigorous medication routine of phenobarbital, Mysoline, and Elipten. His school grades in every subject were also failing, even though he was a highly intelligent child (see Table 2) and was receiving tutoring at home (Sperry et al., 1969). He was also one of the youngest patients to undergo the operation (see Table 1 and Table 2) (Trevarthen & Sperry, 1973).

He was a 13-year-old high school student when he participated in the surgery on April 1, 1965 (Levy & Sperry, 1970). His preoperative test results did not show any evidence of brain

damage, except for an "occasional epigastric aura" and "generalized abnormalities on repeated EEG's" (Sperry et al., 1969). He had the least evidence of brain damage of any patient before the surgery, but he did have a "tendency to aberration of convergence with monocular diplopia of the left eye" that ran in his family and was shared by his father (Trevarthen & Sperry, 1973; Levy et al., 1972).

The operation went smoothly, and he spoke eagerly after regaining consciousness (Sperry et al., 1969). He remained his seemingly intelligent (see Table 2) self after the surgery and continued to interact warmly with Sperry and the other experimenters, being able to comically recite, "Peter Piper picked a peck of pickled peppers" and to joke that he had a "splitting headache" on the day of the operation (Sperry & Gazzaniga, 1967). By 2 days after the surgery he could feed himself and eat solid food, regaining a healthy appetite (Gazzaniga & Sperry, 1967). By 5 days after the surgery he was "ambulatory and well-oriented" (Sperry et al., 1969).

He was able to walk around the hospital on his own a week after the surgery, having the desire to do so much earlier but not being permitted to leave bed by hospital staff before this time (Gazzaniga et al., 1967). At this point in his recovery, he found only a little "apraxic difficulty" in making willed left hand movements (see figures) when asked to do so by researchers, straining to move individual fingers independently (Gazzaniga et al., 1967). This was a dramatic improvement from the months and weeks it took W. J. and N. G. to do the same thing, respectively (Gazzaniga & Sperry, 1967). His recovery was the best of all of the patients, being very quick and devoid of any serious complications or deficits (Trevarthen & Sperry, 1973). By 1969 he had only experienced few epileptic attacks, except for the occasional minor "jacksonian episode" usually involving only the left side of his body, during which he remained conscious (Trevarthen & Sperry, 1973; Sperry et al., 1969).

His personality and mannerisms did not appear to change as a result of the operation (Gazzaniga & Sperry, 1967). He was still very talkative and alert, enjoying verbal problem solving more than signaling or writing the answer (Trevarthen & Sperry, 1973). "Inaccessibility to the language hemisphere," however, caused researchers to believe that "minor hemisphere lateralization" had occurred prior to the operation. According to Trevarthen and Sperry (1973), "He show[ed] right-eye dominance, and a tendency to loose convergence by deviation of the left eye with which he reports monocular diplopia". He also needed to wear reading glasses after the operation (Trevarthen & Sperry, 1973).

He only missed a year of school due to the operation, resuming public school in 1966 at one letter grade below behind his peers (Levy and Sperry, 1970). He performed fairly well in the classroom where he earned passing grades on all of his coursework, aside from mathematics (Levy and Sperry, 1970; Sperry et al., 1969). He had particular trouble with geometry, being forced to move down to a course in "'general mathematics'" (Franco & Sperry, 1977). He also experienced a few problems in memory and attention span due to the operation (Trevarthen & Sperry, 1973).

He was tested more than most of the patients because the type of testing to be conducted often favored his postoperative condition (Sperry et al., 1969, Trevarthen & Sperry, 1973). After thorough testing of L.B., follow-up testing was often conducted with the other patients to obtain comparison data. He also appeared to like the testing environment (Sperry et al., 1969). He was tested in June of 1967 "for cutaneous sensitivity," and was found "to be normal" (Trevarthen & Sperry, 1973). He was still being postoperatively tested into adulthood past age 21 (Zaidel & Sperry, 1976).

Larry was interviewed in 2002 about the impact of dealing with an uncontrollable left hand on the "Alien Hand" broadcast for T. L. C. (Scofield & Reay, 2000). He claims that the more he tries to "control it, the wilder it gets," comparing the problem to a "telegraph line" down through which the messages he sends can not "get through." He believes that the hand has a wicked will of its own, describing instances in which it tried to strangle his friend's dog, prevent him from eating, and slam a door on him. He says that he will eventually win out in a battle of wills with the hand, but that the hand becomes more aggressive as more control is forced on it. To Larry, his left hand is a necessary evil that he has had to accept as a better alternative to a life with uncontrollable epilepsy (Scofield & Reay, 2000).

?*R. Y.*

A car accident at the age of 13 left R. Y. with a "closed head injury" (Perceptual Unity). His generalized convulsive seizures did not begin until the age of 17. He was 43 when the operation was performed on March 7, 1966 (Trevarthen & Sperry, 1973). He recovered relatively well, being able to speak and to obey instructions the day after the surgery.

R. Y. lost some control of his left hand and arm, however, which had not gone away by the time he was post-operatively tested (Trevarthen & Sperry, 1973). This arm and hand occasionally behaved in uncoordinated ways, and frequently both of his hands opposed each other. When tested, his left hand was found to exhibit "periodic involuntary behavior in response to extraneous stimuli" (Trevarthen & Sperry, 1973). His ability to and interest in carrying on a conversation was not impaired by the surgery, but he did have the propensity to repeatedly tell particular stories (Trevarthen & Sperry, 1973). He became quiet and disoriented, though, when under stress or strain. At age 47 he was not employed and was being cared for and

supported financially by his relatives (Trevarthen & Sperry, 1973). He was still being postoperatively tested even after 1976, when he was 49 (Zaidel & Sperry, 1976).

?*C. C.*

C. C. had limited use of his right arm (but see Table 1) due to a brain injury at birth (Zaidel & Sperry, 1976). His personality began to show instabilities at the age of 8, co-occurring with fights at school and general problems with his schoolwork (Levy et al., 1972). At the age of 10 his family discovered that he was inclined to become silent for a period of time, which was occasionally paired with turning his head to the right-hand side, falling, or episodes of unconsciousness (Levy, 1972).

Over the next 3 years his behavior continued to be come more unsociable and his seizures became more serious until both C. C. and his family agreed that he should undergo the operation (Levy et al., 1972). He had the surgery at age 13, and later he still participated in postoperative studies into adulthood (Zaidel & Sperry, 1976). An EEG revealed that damage had occurred in the "temporo-parietal region" of the left hemisphere of the brain (Levy et al., 1972). When postoperatively studied again at age 18, he had been moved into a facility for the care of handicapped persons (Levy et al., 1972).

?*N. W.*

She underwent the operation at age 36 and was still being postoperatively tested at age 43 (Gordon & Sperry, 1968). (See Table 1 & Table 2 for more information)

?*M. K.*

An "enlarged right ventrical" was discovered when M. K. was 8 (Gordon & Sperry, 1968). Her head was scarred in many areas from injuries suffered due to falls during seizures. She may have had serious brain damage in the right hemisphere before the surgery, and an

unusually thick corpus callosum was observed during the surgery. She dragged her left leg when she walked after the surgery (Gordon & Sperry, 1968).

?*N. F.*

N. F. may or may not be the individual portrayed in the "Alien Hand" broadcast as a female in her 20's named Nicola (Scofield & Reay, 2000). N. F did not have full use of her right arm (but see Table 1) as a result of a brain injury caused by a stroke (Zaidel & Sperry, 1976). She was operated on at age 26, when only the anterior 2/3 of her corpus callosum and "hippocampal commissures" were cut in an attempt to leave the splenium intact. She was still being postoperatively tested at age 31 (Zaidel & Sperry, 1976). (See Table 2 for more information)

?*D. M.*

He was operated on at age 23, when only the anterior 2/3 of his corpus callosum and "hippocampal commissures" were cut in an attempt to leave the splenium intact (Zaidel and Sperry, 1976). He was still being post-operatively tested at age 28 (Zaidel and Sperry, 1976). (See Table 1 & Table 2 for more information)

Patients of Vogel

?*D. W.*

He had a "nondominant hemispherectomy" (Franco & Sperry, 1977). He was 7 when the surgery took place. He participated in "carotid amytal studies" that showed his speech center was located in the left side of his brain (Franco & Sperry, 1977). (See Table 1 and Table 2 for more information)

?R. S.

She had a “dominant hemispherectomy” at age 10 (Franco & Sperry, 1977). (See Table 1 and Table 2 for more information)

?V. K.

It was discovered that this individual never developed a corpus callosum by means of a cranial x-ray (Franco & Sperry, 1977). The individual graduated from high school at age 18 and was tested by the researchers at age 22 (Franco & Sperry, 1977).

Potential Patients

? *Robert*

He was portrayed in “Alien Hand” as a boy who was one of the earliest patients in the “California series” and who could write complex words and do arithmetic on a blackboard (Scofield & Reay, 2000). The present writer has found no other mention of him through extensive research, and believes that this may have been due to death at an early age, which did not permit him to participate in many postoperative studies.

?*Donna*

Donna is a middle-aged woman who was interviewed in the year 2000 about life dealing with an uncontrollable left hand on the “Alien Hand” broadcast for T. L. C. (Scofield & Reay, 2000). Donna also believes that her hand has a mischievous will that causes it to do things like “shoot out” when she notices something attractive in her peripheral vision, hold onto her cat and not let go, and open and close drawers. She does not believe that the hand is “evil,” but that it does have the potential to be destructive, as she is always afraid it will hurt her cat. She even went as far as to name her hands after her two brothers; the right hand after the “intellectual”

brother and the left hand after the rowdy brother. She has not quite come to terms with living with her alien hand, however, feeling that it should not be her "enemy" (Scofield & Reay, 2000).

?*Paul or P. S.*

P. S. was the most unusual of the patients because of the highly developed language ability in his right hemisphere (Macalester, 2002). His brain developed this ability sometime before the operation. It is quite rare for the right side of the brain to be involved in the production and comprehension of language, and even more rare for this side of the brain to become highly specialized or even dominant in these skills. He allowed the researchers a glimpse into the thoughts and perceptions of the right hemisphere, which for the most part had lost the ability to communicate outside itself in the other patients (Macalester, 2002).

The case of Paul S. allowed for further investigation into the theory of dual consciousness among the patients, to the point of learning the hopes, desires, thoughts, and emotions held within each hemisphere of the brain (Macalester, 2002). His right brain desired to become a racecar driver, while the left side of his brain hoped to become a "draftsman" (Macalester, 2002). During the Watergate scandal researchers asked P. S. his opinion of president Richard Nixon, receiving disapproval from the right hemisphere and a positive response from the left hemisphere (Macalester, 2002).

Conclusion

General Summary

None of the patients' seizures responded well to drug therapy, eventually deciding to undergo the surgery as a last resort. Of the patients on whom educational information was available, all were found to have at least a high school diploma (Perception of Bilateral, Levy,

Trevarthen & Sperry, 1972). All of the patients who underwent the operation had the procedure at White Memorial Medical Center in Los Angeles, California.

The patients that recovered the quickest and had the fewest complications from the surgery were studied the most (*Dyspraxia*, Gazzaniga, Bogen, Sperry, 1967). Testing of N.G. and L.B. provided most of the information that the experimenters knew about the effects of the surgery by 1970 (Levy & Sperry, 1970). The choice to use these patients may have been due to availability or to the inability of particular patients to perform certain tasks required to conduct the tests. It would seem that for this reason, very little information is available on the patients studied the least or who experienced the most negative reactions to the surgery. Ten of the patients had major improvement in their epilepsy following the operation (Benson & Zaidel, 1985).

Individual Summaries

?*K. S.*

She was a 20-year-old college student, discovered by researchers when hospitalized for hydrocephalus treatment. They were intrigued by her congenital absence of a corpus callosum. She could perform almost all psychological tests well, acting very much like a normal person would. Sperry believed that her ability to adapt to the neurological deficit provided evidence for his theory of brain plasticity.

?*W. J.*

He underwent the surgery on February 4, 1962, at the age of 48, having endured seizures since a WWII combat injury in 1944. He had many other minor medical conditions in addition to epilepsy. His operation was a great success, with the frequency and intensity of his seizures decreasing as a result. Psychological testing revealed that the two sides of his brain could not

communicate, results typical of all of the patients, and that he suffered from alien hand syndrome. He was the first patient and one of the most studied patients.

?*N. G.*

She began to have seizures at the age of 18, and underwent the surgery on September 5, 1963, at the age of 30. Psychological testing revealed that the two sides of her brain could not communicate, results typical of all of the patients. Her operation was a great success, with the frequency and intensity of her seizures decreasing as a result. She was able to return to her responsibilities as a wife and mother, living a normal life after her recovery.

?*A. A.*

His seizures began in infancy, probably resulting from a brain injury at birth. He underwent the surgery at the age of 14, on October 14, 1964, which produced swelling and damage to the right frontal lobe of his brain. No information on seizure reduction in A. A. could be found. Psychological tests did show, however, that his intellectual abilities decreased as a result of the operation. He attended a school for the handicapped, beginning in 1966.

?*L. B.*

His seizures began in early childhood, probably resulting from brain damage at birth. He underwent the surgery at the age of 13, on April 1, 1965, recovering more quickly than any other patient. His operation was a great success, with the frequency and intensity of his seizures decreasing as a result. Psychological testing revealed that the two sides of his brain could not communicate, results typical of all of the patients. He was one of the most enthusiastic and friendly patients, enjoying the testing situation as much as the researchers enjoyed testing him.

?*R. Y.*

A car accident left him with brain damage when he was 13 years old, with seizures beginning four years later. He underwent the surgery at the age of 43, on March 7, 1966, recovering well from the operation. The only significant complication was the development of alien hand syndrome. Psychological testing revealed that the two sides of his brain could not communicate, results typical of all of the patients. No information on seizure reduction could be found, but the present writer did discover that R. Y.'s family cared for him after the operation due to his inability to get a job and function independently.

?*C. C.*

The initial occurrence of seizures around age 10 may have stemmed from a brain injury at birth, which also inhibited use of his right arm. He underwent the surgery at age 13, resulting in slight damage to the left hemisphere of his brain. Psychological testing revealed that the two sides of his brain could not communicate, results typical of all of the patients. No information on seizure reduction could be found. The present writer did find that C. C. was unable to care for himself after the operation, and thus was moved into a facility for the care of handicapped persons.

?*N. W.*

She underwent the surgery at age 36. Psychological testing revealed that the two sides of her brain could not communicate, results typical of all of the patients. No information on seizure reduction could be found. She performed well on the WAIS IQ test following the operation.

?*M. K.*

The onset of her seizures may have begun due to an enlarged right ventrical. M. K. most likely suffered significant brain damage before the surgery, and she experienced motor difficulties after the surgery. Psychological testing revealed that the two sides of her brain could

not communicate, results typical of all of the patients. No information on seizure reduction could be found.

?*N. F.*

The onset of her seizures may have been due to a stroke, which also inhibited use of her right arm. She underwent the surgery at age 26, and was still participating in postoperative testing at age 31. Psychological testing revealed that the two sides of her brain could not communicate, results typical of all of the patients. No information on seizure reduction could be found.

?*D. M.*

He underwent the surgery at age 23, and was still participating in post-operative testing at age 28. Psychological testing revealed that the two sides of his brain could not communicate, results typical of all of the patients. No information on the initial onset of seizures or seizure reduction following the operation could be found.

?*D. W.*

He underwent the surgery at age 7. Participation in "carotid amytal studies," showed that the speech center in his brain was located in the left hemisphere. No information on the initial onset of seizures or seizure reduction following the operation could be found.

?R. S.

She underwent the surgery at age 10. Psychological testing revealed that the two sides of her brain could not communicate, results typical of all of the patients. No information on the initial onset of seizures or seizure reduction following the operation could be found.

?V. K.

An x-ray revealed that this individual never developed a corpus callosum. The individual graduated from high school at age 18 and still participated in testing with researchers at age 22. No information on psychological testing was found.

? *Robert*

He underwent the surgery as a boy. Psychological testing revealed that he could write complex words and do arithmetic on a blackboard. The present writer found very little information regarding his case study, believing that he may not have lived very long after the surgery.

?*Donna*

Donna underwent the surgery in her teens or twenties, developing alien hand syndrome as a result. No information on the initial onset of seizures, seizure reduction following the operation, or psychological testing could be found.

?*Paul or P. S.*

Psychological testing revealed that P. S. was able to voice the thoughts and desires produced by both sides of his brain, due to the unusual presence of language processing centers in both hemispheres. No information on the initial onset of seizures, seizure reduction following the operation, or psychological testing could be found.

References

Benson, F. D., & Zaidel, E. (1985). *The Dual Brain: Hemispheric Specialization in Humans*. New York: Guilford Press.

Bogen, J. E., Fisher, E. D., & Vogel, P. J. (1965, December 20). Cerebral commissurotomy: A second case report. *Journal of the American Medical Association, 194*, 160-161.

Bogen, J. E., & Vogel, P. V. (1962). Cerebral commissurotomy in man: Preliminary case report. *Bulletin of the Los Angeles Neurological Society, 27*, 169-172.

Franco, L., & Sperry, R. W. (1977). Hemisphere lateralization for cognitive processing of geometry. *Neuropsycholgia, 15*, 107-114.

Gazzaniga, M. S. (2002). Whole-brain interpreter. *Gazzaniga on Whole Brain*. http://pegasus.cc.ucf.edu/~fle/gazzaniga.html

Gazzaniga, M. S., Bogen, J. E., & Sperry, R. W. (1962). Some functional effects of sectioning the cerebral commissures in man. *Proceedings of the National Academy of Science, 48*, 1765-1769.

Gazzaniga, M. S., Bogen, J. E., & Sperry, R. W. (1965). Observations on visual Perception after deconnection of the cerebral hemispheres in man. *Brain, 88* (*Part II*), 221-236.

Gazzaniga, M. S., Bogen, J. E., & Sperry, R. W. (1967, June). Dyspraxia following division of the cerebral commissures. *Archives of Neurology, 16*, 606-612.

Gazzaniga, M. S., & Sperry, R. W. (1967). Language after section of the cerebral commissures. *Brain, 90* (*Part I*), 131-148.

Gordon, H. W., & Sperry, R. W. (1969). Lateralization of olfactory perception in the

surgically separated hemispheres of man. *Neuropsychologia, 7,* 111-120.

Levy, J., & Sperry, R. W. (1970). Crossed temperature discrimination following section of forebrain neocortical commissures. *Cortex*, *6*, 349-361.

Levy, J., Trevarthen, C., & Sperry, R. W. (1972). Perception of bilateral chimeric figures following hemispheric deconnection. *Brain, 95* (*Part I*), 61-78.

Macalester. (2002). Behavior of split-brain patients. *Behavior*. http://www.macalester.edu/~psych/whathap/UBNRP/Split_Brain/Behavior.html

Nebes, R. D., & Sperry, R. W. (1971). Hemispheric deconnection syndrome with cerebral birth injury in the dominant arm area. *Neuropsychologia*, *9*, 247-259.

Pietsch, P. (2002). Splitting the human brain. *Split-Brain*. http://www.indiana.edu/~pietsch/split-brain.html

Scofield, J. (Director), & Reay, J. (Executive Producer). (2000). Alien Hand [Television Broadcast]. New York: The Learning Channel.

Sperry, R. W. (1966, February). Brain research: Some head-splitting implications. *The Voice*, *15*, 11-16.

Sperry, R. W. (1968). Hemisphere deconnection and unity in conscious awareness. *American Psychologist*, *23*, 723-733.

Sperry, R. W. (1968). Plasticity of neural maturation. *Developmental Biology Supplement*, *2*, 306-307.

Sperry, R. W. (1975, August 9). Left-brain, right-brain. *Saturday Review*, 30-33.

Sperry, R. W. (1976). Hemispheric specialization of mental faculties in the brain of man. In T. Barber (Ed.) *Advances in Altered States of Consciousness & Human Potentialities*, *1*, 53-63. New York: Psychological Dimensions.

Sperry, R. W., & Gazzaniga, M. S. (1967). Language following surgical disconnection of the hemispheres. *Brain Mechanisms Underlying Speech and Language*. US: Grune & Stratton.

Sperry, R. W., Gazzaniga, M. S., & Bogen, J. E. (1969). Interhemispheric relationships: The neocortical commissures; syndromes of hemisphere disconnection. *Handbook of Clinical Neurology*, *4*, 273-290.

Sperry, R. W., Vogel, P. J., & Bogen, J. E. (1967, October 22-28). Syndrome of hemisphere deconnection. *Second Pan-American Congress of Neurology*. In San Juan, PR.

Trevarthen, C., & Sperry, R. W. (1973). Perceptual unity of the ambient visual field in human commissurotomy patients. *Brain*, *96*, 547-570.

Zaidel, D., & Sperry, R. W. (1977). Some long-term motor effects of cerebral commissurotomy in man. *Neuropsychologia*, *15*, 193-204.

Appendix

Table 1

The Split-brain Patients at a Glance

Patient	Name	Handedness	Education	Corpus Callosum	Sex	Age at Surgery/ 1st Studied
K. S.	Katie?	Right?	College	Absent	F	N/A, 20
W. J.	Walter	Right (but could write fairly well w/ left)	HS/self	Severed 2/4/62	M	48
N. G.	*	Right (& footed, as were her parents and grandparents)	HS	Severed 9/5/63	F	30
A. A.	*	Right (see text)	College	Severed 10/14/64	M	14
L. B.	Larry	Right (same as parents and siblings, except for older half-brother)	HS	Severed 4/1/65	M	13
R. Y.	*	Right	*	Severed 3/7/66	M	43
C. C.	*	Right	HS	Severed ~1967	M	13
N. W.	*	Right	*	Severed ~1969	F	36
M. K.	*	*	*	Severed	F	*
N. F.	Nicola?	Right	College?	Severed ~1971	F	26
D. M.	*	Right	*	Severed ~1971	M	23
*	Robert	Right?	*	Severed 1960's	M	Young boy
*	Donna	Right?	*	Severed	F	*

P. S.	Paul	*	*	Severed ~1973	M	*
D. W.	Robert?	Right	*	Severed 1965	M	7
R. S.	*	Right	*	Severed 1971	F	10
V. K.	*	*	HS	Absent	*	N/A, 22

Note. Information in table was obtained from the sources listed in references.
* = Unknown

Table 2

The Split-brain Patients at a Glance (cont.)

Patient	Occupation	Cause of Seizures	WAIS or WISC scores/ When Tested	Doctor(s)
K. S.	Office clerk	N/A	(WAIS) 96=perform., 111=verbal, 104=total/ 2 months after lack of c. c. discovered	Bogen and Vogel
W. J.	Payroll clerk	Head injury in battle	(WAIS) 113 IQ/ before WWII; no sig. IQ change after operation	Bogen and Vogel
N. G.	House wife	Genetic/developmental	(WAIS) 73 IQ/ preoperative; 69= perform., 87=verbal, 78=total/ 5/67; 83=verbal, 71= perform., 77=total/ 8/68	Bogen and Vogel
A. A.	*	Brain injury at birth	(WAIS) 77=verbal, 82=perform., 78=total/ 8/68	Bogen and Vogel
L. B.	*	Brain injury at birth	(WAIS) 115 IQ/ preoperative; 110=verbal, 100=perform., 106=total/	Bogen and Vogel

			5/68; 106 IQ/ 1977	
R. Y.	N/A	Car accident head injury	(WAIS) 99=verbal, 79=perform., 90=total/ 8/68; 90 IQ/1976	Bogen and Vogel
C. C.	N/A	Brain injury at birth	(WAIS) 77 IQ/ 1977	Bogen and Vogel
N. W.	*	*	(WAIS) 93 IQ/ 1977	Bogen and Vogel
M. K.	*	Enlarged right ventrical?	*	Bogen and Vogel
N. F.	*	Brain injury from stroke	(WAIS) 83 IQ, higher verbal than perform/ postoperative	Bogen and Vogel
D. M.	*	*	(WAIS) 76 IQ, higher verbal than perform./ postoperative	Bogen and Vogel
Robert	*	*	*	Bogen and Vogel?
Donna	*	*	*	Bogen and Vogel?
P. S.	*	*	*	Bogen and Vogel?
D. W.	*	*	(WISC) 67 IQ, higher on verbal than perform. /1977 at age 19	Vogel

R. S.	*	*	(WISC) 56 IQ, higher on verbal than perform./ 1977 at age 16	Vogel
V. K.	*	N/A	*	Vogel

Note. Information in table was obtained from the sources listed in references.
* = Unknown

Table 3

The Split-brain Patients at a Glance (cont.)

Patient	Recovery	Success of Operation	Number of Sources Found
K. S.	N/A	N/A	3
W. J.	Few lasting side-effects, full recovery within 1 year	Excellent, no generalized convulsions within 30 months	15
N. G.	Quick, no serious complications, full recovery within 6 months	No generalized convulsions within 2 years (medications needed initially to control), seizures almost disappearing within 7 years	14
A. A.	Many complications including: swelling, motor and speech problems, etc.	*but assumed that was a success (surgeons do not say otherwise)	7
L. B.	Accelerated, best of all patients, back to school within the same year	Only a few mild seizures within 4 years of the operation	14
R. Y.	Quick, uneventful,	* but assumed that	4

	poor control of left hand/arm	was a success (surgeons do not say otherwise)	
C. C.	No complications mentioned, aside from slight damage to temporo-parietal region	* but assumed that was a success (surgeons do not say otherwise)	4
N. W.	*	* but assumed that was a success (surgeons do not say otherwise)	3
M. K.	Dragged left leg after surgery	* but assumed that was a success (surgeons do not say otherwise)	1
N. F.	*	* but assumed that was a success (surgeons do not say otherwise)	2
D. M.	*	* but assumed that was a success (Surgeons do not say otherwise)	2

Robert	*	*	1
Donna	*	Seizures less severe/frequent	1
P. S.	*	* but assumed that was a success (surgeons do not say otherwise)	1
D. W.	*	* but assumed that was a success (surgeons do not say otherwise)	1
R. S.	*	* but assumed that was a success (surgeons do not say otherwise)	1
V. K.	N/A	N/A	1

Note. Information in table was obtained from the sources listed in references.
* = Unknown

A “Schematic representation of some of the main cerebral functions found to be lateralized following hemisphere disconnection.”

From: Benson, F. D., & Zaidel, E. (1985). *The Dual Brain: Hemispheric Specialization in Humans.* New York: Guilford Press.

From:

Sperry, R. W. (1975, August 9). Left-brain, right-brain. *Saturday Review*, 30-33.

From: Sperry, R. W., Gazzaniga, M. S., & Bogen, J. E. (1969). Interhemispheric relationships: The neocortical commissures; syndromes of hemisphere disconnection. *Handbook of Clinical Neurology*, *4*, 273-290.

Both from: Benson, F. D., & Zaidel, E. (1985). *The Dual Brain: Hemispheric Specialization in Humans.* New York: Guilford Press.

From: Gazzaniga, M. S., Bogen, J. E., & Sperry, R. W. (1967, June). Dyspraxia following division of the cerebral commissures. *Archives of Neurology, 16*, 606-612.

From: Sperry, R. W., Gazzaniga, M. S., & Bogen, J. E. (1969). Interhemispheric relationships: The neocortical commissures; syndromes of hemisphere disconnection. *Handbook of Clinical Neurology*, *4*, 273-290.

From: Nebes, R. D., & Sperry, R. W. (1971). Hemispheric deconnection syndrome with cerebral birth injury in the dominant arm area. *Neuropsychologia, 9,* 247-259.

From: Sperry, R. W., Gazzaniga, M. S., & Bogen, J. E. (1969). Interhemispheric relationships: The neocortical commissures; syndromes of hemisphere disconnection. *Handbook of Clinical Neurology*, *4*, 273-290.

From: Benson, F. D., & Zaidel, E. (1985). *The Dual Brain: Hemispheric Specialization in Humans*. New York: Guilford Press.

From: Sperry, R. W., Gazzaniga, M. S., & Bogen, J. E. (1969). Interhemispheric relationships: The neocortical commissures; syndromes of hemisphere disconnection. *Handbook of Clinical Neurology*, *4*, 273-290.

From: Nebes, R. D., & Sperry, R. W. (1971). Hemispheric deconnection syndrome with cerebral birth injury in the dominant arm area. *Neuropsychologia*, *9*, 247-259.

From: Benson, F. D., & Zaidel, E. (1985). *The Dual Brain: Hemispheric Specialization in Humans*. New York: Guilford Press.

From: Benson, F. D., & Zaidel, E. (1985). *The Dual Brain: Hemispheric Specialization in Humans*. New York: Guilford Press.

From: Benson, F. D., & Zaidel, E. (1985). *The Dual Brain: Hemispheric Specialization in Humans*. New York: Guilford Press.