Proceedings of the American Philosophical Society

Held at Philadelphia for Promoting Useful Knowledge

VOLUME 143, NUMBER 3 SEPTEMBER 1999

THE AMERICAN PHILOSOPHICAL SOCIETY

INDEPENDENCE SQUARE: PHILADELPHIA

1999

ROGER WOLCOTT SPERRY

(20 August 1913–17 April 1994)

Courtesy of Mrs. Roger W. Sperry

ROGER WOLCOTT SPERRY

(20 August 1913–17 April 1994)

Roger Sperry was born in Hartford, Connecticut, on 20 August 1913. He graduated from Oberlin College in 1935 as an English major. After obtaining an M.A. in psychology at Oberlin, he went on to a Ph.D. in zoology at the University of Chicago in 1941. Experience there, at Harvard, at the Yerkes Laboratory (then in Florida), and at NIH culminated in his appointment in January 1954 as the first Hixon Professor of Psychobiology at Caltech. He remained on the faculty at Caltech until his death on 17 April 1994 from aspiration pneumonia superimposed on a long-standing neurospasticity syndrome.

It was in 1981 that Sperry shared the Nobel Prize with David Hubel and Torsten Wiesel, in part for his work with the human split-brain; his evidence for complementary hemispheric specialization was singled out. He had already been awarded in one year, 1979, the Wolf Prize for Medicine, an Albert Lasker Award in Basic Medical Research, and the Ralph W. Gerard Prize of the Society for Neuroscience. The last was presented by Victor Hamburger, emeritus professor of biology at Washington University, who wrote (*Neuroscience Newsletter*, December 1979): "I know of nobody else who has disposed of cherished ideas of both his doctoral and post-doctoral sponsors [Weiss and Lashley], both at that time the acknowledged leaders in their fields . . . it is given to few scientists to accomplish radical conceptual conversions in two different fields of inquiry. Perhaps only veterans of my vintage can fully appreciate the profound changes in the neurobiological landscape. . . ." Other evaluations of his work are included in the Sperry memorial issue of *Neuropsychologia* (October 1998).

Sperry challenged the 1930s belief in the all-powerful role of functional activity for the creation of neural circuitry with a long series of brilliant experiments. These began with his transposition of nerves in the rat hind leg, in which the nerves for flexion and for extension were switched. Forever after, when the bottom of the foot was injured, the leg straightened instead of pulling up. As the foot ulcer worsened, the rat pushed down ever harder. Surprisingly, in Sperry's words, "No adaptive functional adjustment of the nervous system took place." His

movie of these rats quickly brought Sperry to the attention of the neurobiology community. (It is noteworthy that the necessary funds were provided by the Penrose Fund of the American Philosophical Society.) Then came his dramatic experiments with salamanders, whose optic nerves could regenerate. Roger cut the nerves and rotated the eyeballs 180°. When vision returned, the salamanders saw everything upside down for the rest of their lives. In the words of Charles Hamilton, he "showed conclusively that neural connections are reestablished under genetic control following experimental interruption and also, by implication, during embryonic development."

As early as 1941, Sperry suggested that chemical gradients were responsible for the orderly regrowth (and by implication the original growth) of nerve fiber connections. This came to be known as the chemoaffinity theory; it was later developed by Sperry in more detail (*Proc. Nat. Acad. Sci.*, October 1963). In V. Hamburger's presentation of the Gerard Prize in 1979, he said: "The chemoaffinity theory soon found wide recognition [and] is one of the few important general unifying principles in today's developmental neurobiology despite the fact that its molecular basis is unknown."

The split-brain experiments leading to the Nobel Prize started with the problem of interocular transfer. That is, if one learns with one eye how to solve a problem, then, with that eye covered and using the other eye, one already knows how to solve the problem. This is called "interocular transfer of learning." Of course, the learning is not *in* the eye and then transferred to the other eye, but that's the way it's usually described. That this occurs seems obvious; but it is in the questioning of the obvious that discoveries are often produced. In this case the question is, how can the learning with one eye appear with use of the other? Sperry's scheme was to split the optic chiasm so the right eye goes to the right cerebral hemisphere and the left eye to the left hemisphere, and also to cut the corpus callosum between the two hemispheres. This produced a "split-brain cat." The cat can be trained with the right eye to distinguish a triangle from a square while the left eye is covered. After the cat has learned the problem one can test the left eye with the right eye covered; the split-brain cat has to learn all over again, that is, it starts at 50 percent chance. The learning curve for the left eye (and left hemisphere) is very similar to the learning curve for the right eye. Since the cat has to learn all over from the beginning with the second eye, the cat can be trained to pick the square instead of the triangle when using the second eye. It then depends on which eye is open where the cat goes. Each hemisphere has developed a different memory about what is correct.

Sperry's experiments with cats and later with monkeys paved the way for cutting the corpus callosum in humans as a treatment for

severe epilepsy. After the patients recovered from the operation and were no longer having seizures, they were generally willing to come to the Sperry laboratory, taking part in a series of experiments extending over several decades. The results can be summarized as follows:

Social Ordinariness. One of the most remarkable results is that in spite of severance of two hundred million nerve fibers, in ordinary social situations the patients are indistinguishable from normal. Special testing methods are needed to expose their deficits.

Lack of Interhemispheric Transfer. A wide variety of experiments have shown that the human subjects are in this respect the same as split-brain cats and monkeys. A typical example is the inability to retrieve with one hand an object palpated with the other.

Hemispheric Specialization Effects. The hemispheric specialization typical of human subjects results in phenomena not seen in split-brain animals. A typical example is the inability of right-handers to name or describe an object in the left hand, even when it is being appropriately manipulated.

Compensatory Phenomena. Split-brain subjects progressively acquire strategies for circumventing their interhemispheric transfer deficit. A common example: the patient speaks out loud the name of an object palpated in the right hand. Because the right hemisphere can recognize many individual words, the object can then be retrieved with the left hand.

Getting to Know Him

It is not a simple matter to do justice to Roger Sperry's complexity. It may be best to tell a few anecdotes that reflect my impression of Roger's genius, style, and dour demeanor.

The first time I saw Roger was when he gave a Sigma Xi lecture at Caltech in 1953. He lucidly described and astoundingly illustrated the retained discriminative ability of cats with extensive alterations of visual cortex. A former biology division chairman has said that it was the best scientific talk he ever heard. Shortly thereafter, Sperry was appointed Hixon Professor.

My first personal contact with Roger was in 1955, when I was a graduate research assistant to Caltech professor Anthony Van Harreveld, whose lab and office were just down the hall from Roger's. Those split-brain cats were mind-boggling; they made a profound impression on everybody. It was for me the most influential scientific experiment that I have ever seen or known about. It set the course of my life.

Three years later, having trained in general surgery, I returned to

Van Harreveld, as a postdoc in neurophysiology. It was necessary for me to go up and down the hall several times a day. Usually when I passed Roger's office, the door was open. Sometimes he was reading or doodling on a pad. Sometimes he was sitting back with his feet on the desk, apparently staring off into space. Then, one day, he was gone—into the lab. Not long after, there was a seminar concerning the work of Attardi and Sperry on optic nerve regeneration. The slides were sections of goldfish brain, stained a bluish-black except for the regenerating fibers. The regenerating fibers, snaking their way through the scarred jumble of the optic chiasm, were stained a brilliant pink. Around the front of the optic lobe they went, and then they dove abruptly into their intended targets. It was spectacular! Unfortunately, when this work was published, in *Experimental Neurology*, the pictures were reproduced in black and white. That was in 1963, five years after the appearance of the abstract in *Anatomical Record* in 1958. Such a long delay was not unusual for Roger. He often kept papers on his desk for a long time, for several reasons. One was that he liked to have some idea of how the follow-up experiments were developing before finalizing the discussion of the earlier paper. Of course, he always published an abstract as soon as possible to establish priority, so he could take as many years as needed to do various controls and rewriting. He did not always delay. One day he said, "We have to send this [olfactory] paper in immediately." Why? "Because I have just refereed a paper with a similar experiment in rats. People know that with human subjects, we can do in a few weeks what would take many months in rats. If we delay, certain people might think that I got the idea when refereeing the rat paper." Roger seemed to think of everything! I idolized him and hung on his every word, of which there were not very many!

That leads to another story from that time. A group of us were out carousing on New Year's Eve. We returned to Roger and Norma's home just in time for an early New Year's Day breakfast. I volunteered to make some scrambled eggs. Somewhere I had read that Worcestershire sauce would pep up scrambled eggs. Unfortunately, I had neglected to take note of the appropriate amount. When the eggs were served they were a homogeneous tan color. After my first bite, I was horrified at the thought of what Roger might think. Another minute went by as Roger took a second and then, thoughtfully, a third bite. He then turned to me and said, "Joe, these *are* scrambled eggs."

When I returned to his lab from a neurophysiology meeting that same year, he seemed interested in my report. After listening just a few minutes he asked, "Anything that would alter our views?" I replied, "Enrich, perhaps, but not alter." He nodded and changed the subject.

In 1960, I was working at the County Hospital. I took to him an essay on epilepsy entitled, "A Rationale For Splitting the Human Brain." His laconic comments included, "Maybe you should change the title." Also, "Look up those papers by Akelaitis." When I did that, it appeared that the callosal surgery by Van Wagenen twenty years before had actually turned out better than the prevailing medical opinion (of about 1960) held. This led eventually to a nearly-thirty-year joint effort studying patients who had had the split-brain operation to treat their medically intractable epilepsy.

Once, after members of an NIH site visit team had left, I asked Roger what he had said to influence their decision. "Three of the five were psychologists," he replied. "I said that this was the only psychology program at Caltech and if it were not supported there wouldn't be any." This was not simply a ploy. Roger sometimes dryly alluded to being surrounded by molecularists plugging away without any interest in what he called "the big problems." He meant by this both problems of society and problems *identified by psychologists*, requiring physiological answers, especially a neurobiological explanation of consciousness.

Roger's emphasis on consciousness was long present in his thoughts. This emphasis became progressively more evident in his writing. He felt his first paper to assert forcefully what he called the "Central Issue" was his chapter in *New Views of the Nature of Man* (University of Chicago Press, 1965). In this chapter he asserted that the central issue is the nature of consciousness, and that a correct model of brain function could not be constructed "without including consciousness in the causal sequence." He urged what he called a mentalist position, which meant that "overall pattern effects in brain dynamics" direct and govern neuronal traffic. He suggested that his mentalist position illuminated the problem of free will by embedding self-determination firmly in the flow of physical forces. He believed that he was offering "an objective, explanatory model of brain function [that] affirms age old humanist values," while at the same time opening established moral values to "the free winds of scientific skepticism and inquiry."

Roger continued along this path ever more energetically so that by 1980 almost all of his writing was devoted to the central issue of consciousness. Specifically, he continued to dispute "the idea that the objective physical brain process is causally complete in itself without reference to conscious or mental forces" (in *Neuroscience*, 1980).

Even by 1970, Roger had become widely recognized for the above views, which were attracting philosophical attention, both pro and con.

It was in 1970 that Oliver Zangwill, professor of psychology at Cambridge, the premier psychologist in England and possibly in the

English-speaking world, came to Caltech for the entire month of August, at Sperry's invitation. Oliver was bent on seeing the split-brain patients in person, and Roger wanted Oliver's reaction to his efforts to bring science into the humanities, and vice versa.

After several weeks of socializing with Oliver, I was emboldened to ask him, "What are you telling Roger?" "I'm a bit concerned," he confided, "that if he goes on in this vein it is likely to diminish the impact of his many marvelous achievements."

"How did he react to that?" I asked.

"Very little," was the stiff-lipped reply.

Oliver Zangwill's prediction was fulfilled by the time Sperry was honored with a party at Caltech in 1982 for having brought to the biology department its fourth Nobel award. Those who had not known him early on assumed that "he's gone religious like so many old folks." By 1990, even those older Caltech professors who had been his friends for nearly forty years had given up trying to defend or even to understand "the philosophy of his later years," as one of them put it.

How Could Sperry Be a Mentalist but Not a Dualist?

My answer to this question is based on the difference between epistemology and ontology. Roger was an epistemologic dualist but *not* an ontologic dualist. He considered himself a monist because "monism . . . says 'no' to an independent existence of conscious mind apart from a functioning brain" (*Neuroscience*, 1980).

Roger was an epistemologic dualist twice over, in two different ways. The first duality concerns our abilities to understand the outside world. We acquire those abilities in two ways. The first source of knowledge is our phylogenetic history—that is, our brains come genetically equipped with wired-in organizational principles, including rules for making choices and weighing evidence, even for weighing consequences of contemplated actions. Roger championed this view.

But there is a second source of understanding, namely, experience. Roger was fully aware of the importance of ontogenetically acquired information, including rules for weighing evidence and consequences.

There is another epistemologic duality: for the foreseeable future, our knowledge of what goes on inside brains will come from *two* sources, introspection *and* observation. One way to illustrate the difference between sources of knowledge is to consider the split-brain patient LB. LB reads the split-brain literature and has studied his own brain MRI; his talking left hemisphere has a great deal of indirect information about his own right hemisphere. Indeed, LB has more of an objective understanding of right hemisphere function than most of the media folk who have expounded on this subject. What his left hemisphere does *not* have is the extent of direct knowledge of his right hemisphere contents that most of *our* left hemispheres have of our right hemispheres. As Sperry put it, "About the only instrument known at present by which one brain can plug into and read out directly the conscious experience of another brain, is the corpus callosum."

Mentalistic Materialism

Many psychologists find useful the concept of "mental states." Those who use such terms (including Sperry) generally intend that "mind" is a four-letter word synonymous with "mentation," which is itself a shorthand way of referring to a collection of processes rather than the name of a thing.

To understand Sperry's philosophy it is essential to understand that speaking of Mind carries *no* implication of ontologic dualism. One can be both a physicalist ontologically and a mentalist epistemologically.

The philosopher Owen Flanagan prefers to describe his own view as "naturalism." He wrote, "Naturalism is the view that the mind-brain relation is a natural one. Mental processes are just brain processes." Elsewhere he said, "Any science, therefore, that fails to talk about mental events and processes will not be remotely adequate." Here, bluntly stated, is one of Roger Sperry's basic claims, an assertion, as Oliver Zangwill realized, that was almost guaranteed to offend many of his Caltech colleagues.

Physicalism Versus Materialism

Many people use the terms "physicalism" and "materialism" interchangeably. I find it helpful to distinguish them. Roger Sperry was a physicalist and most of his students are physicalists.

One way to express this view is to claim that nothing mental could have been otherwise without something physical having been otherwise. This is physicalism; it asserts nothing about the absence or possibility of non-material influences on brain (and *subsequently* on mind). By contrast, materialism is not only physicalistic but goes on to deny explicitly any non-material influences.

What distinguishes Sperry's view from most physicalist approaches that recognize Mind is the great importance he attached to the influence *back onto* brain of mentation. This can be called "retroac-

tion," being half of what Sperry himself called "monistic interactionism" and described as follows:

> . . . the individual nerve impulses and associated elemental excitatory events are obliged to operate within larger circuit-system configurations [which] have their own dynamics in cerebral activity [and] govern the flow of nerve impulse traffic by virtue of their encompassing emergent properties. . . . Obviously, it also works the other way around, that is, the conscious properties of cerebral patterns are directly dependent on the action of the component neural elements. . . . The neurophysiology, in other words, controls the mental effects, and the mental properties in turn control the neurophysiology.

What could be the mechanism of retroaction? Could it be some form of electric or magnetic fields constraining neuronal action? Roger himself produced evidence against this mechanism. If Roger Sperry was right, finding an answer to the retroaction problem would be another revolutionary advance in our understanding of brain/mind relations.

While I was at the County Hospital, one of my projects involved some behavioral experiments with rats, with results I could not understand. It seemed to me that if anybody could help it would be Roger. I brought my data up to the Institute. After some technical comments he mumbled, "If you keep working with that you might come up with something dramatic."

Roger Sperry's facility for "coming up with something dramatic," time after time, in a variety of contexts, did not arise simply because he kept in mind the value of a decisive, counterintuitive result. Nor was it only because he was an expert experimentalist, nor only because he was at the same time a creative and highly disciplined presenter. What was essential was that he was among the deepest, the most profound neurothinkers of our time.

ELECTED 1974

JOSEPH E. BOGEN
Clinical Professor of Neurological Surgery
University of Southern California
Adjunct Professor of Psychology
University of California at Los Angeles
Visiting Professor of Biology
California Institute of Technology

For full citations, please see the author's essay in *Neuropsychologia* 36 (10) (1998): 1089–96.

KENNETH V. THIMANN

(5 August 1904–15 January 1997)