Introduction

The question at the heart of this study has a history of more than two thousand years; while it has invited solution after solution, it never seems to get solved. How is "the marvellous phenomenon of the mind" produced from "the enigmatic three-pound mass of tissue known as the brain"?[1] How can chemicals, cells, electrical signals – in short, matter – give rise to our consciousness, our thoughts, dreams, hopes and fears? How can two such different categories of existence bear any relationship to each other, much less be born, live, and die together?

Why the mind-body problem has remained so peculiarly intransigent despite repeated attacks is in itself a question worthy of consideration; that it continues to invite attacks cannot be disputed. In his recent book *Consciousness Explained,* Daniel Dennett asked, "how could the brain be the seat of consciousness?" and then proceeded to give the following answer:

> It turns out that the way to imagine this is to think of the brain as a computer of sorts. The concepts of computer science provide the crutches of imagination we need if we are to stumble across the *terra incognita* between our phenomenology as we know it by "introspection" and our brains as science reveals them to us.[2]

Meanwhile, John Searle has announced his own "simple" solution to the mind-body problem, one he hopes will "put the final nail in the coffin of the theory that the mind is a computer program."[3] Lest we conclude that the problem is today mainly for philosophers, the biologist Gerald Edelman has written a trilogy describing what he calls the only "biological" solution to the mind-body problem.[4] And the neurologist Oliver Sacks has called for a theory of brain and mind that does justice to the dignity of the soul.[5]

In this study, I have chosen to examine a brief segment of this long history in which several different solutions to the mind-body problem were proposed by

[1] Steven Levy, "Dr. Edelman's Brain," *The New Yorker,* May 2, 1994: 62.
[2] Daniel Dennett, *Consciousness Explained* (Boston: Little, Brown, 1991), 433.
[3] John Searle, *The Rediscovery of the Mind* (Cambridge: MIT Press, 1992), 1, xi.
[4] Levy, 62.
[5] Oliver Sacks, "Neurology and the Soul," *The New York Review of Books,* November 22, 1990: 50.

psychologists and biologists. The controversies that erupted among them took place between 1910 and 1955 in various American universities, and have one individual at their focal point: the American comparative psychologist Karl Spencer Lashley.[6]

Lashley's solution to the mind-body problem is one that many people today would probably find congenial: the mind is nothing but the brain; there is no immaterial soul; thoughts and feelings can be explained entirely in terms of neurons and chemicals. But I have not chosen to concentrate on Lashley simply because of the similarity of his ideas to our own. Rather, his story shows us that much more is at stake in the solution to this persistent problem than a straightforward desire to figure out the relationship between mind and brain. The solution Lashley proposed was based on hard experimental evidence: his theories rested on what he believed were the facts. But his positions in the different controversies, his ideas about how the brain worked, were not solely the products of his laboratory. They were also the result of his position within his relatively young profession – psychology – and of his political and social ideals. The story of Lashley's life and work offers a casestudy in the continuous interconnections between scientific inquiry, political ideology, and social context.

To demonstrate the relationship between Lashley's context – his beliefs about the world, his hopes for society and for his profession – and his position in these debates is, then, one of the main tasks I have set myself. Lashley made a point throughout his career of constructing a radical separation between his science and his politics. For him, the problem of mind – indeed, all of science – was independent of culture, of social interests, of moral implications. One of my purposes is to show that the science and its context were inseparable. In doing so, I argue that we must begin to broaden the focus of our interest in the mind-body problem: not only to look for an answer, but also to ask why so many people for such a long time have been interested in an answer, and to ask why their answers look the way they do. We must not simply accept one solution or another, but ask what historical conditions made such solutions possible. We should try to understand not only the facts, but also how the facts get constructed.

Though his name is little known today, especially among nonscientists, Lashley was the premier American brain researcher of the first half of the twentieth century. In his lifetime, he was celebrated as the author of an innovative and influential theory of brain function: the idea that the brain functions as a whole, not as a congeries of discrete capacities. This conception rested on a series of

[6] The discipline of psychology before the Second World War was focused on questions relating to the mind, its functions and capacities and its relation to the body, rather then on therapeutics as it is today. See Michael M. Sokal, "The Gestalt Psychologists in Behaviorist America," *American Historical Review* 89 (1984): 1241.

Karl S. Lashley (photograph probably taken around 1950). (Reprinted from *The Neuropsychology of Lashley.* Used with the permission of the publisher.)

experiments that Lashley conducted on the brains of rats, experiments so meticulous that they served as a model of objectivity for a generation of investigators.

Revered as he was in life, since his death in 1958 Lashley's stature has only increased, especially among the scientists who followed his lead. Although certain of his specific findings have been disproved by later research, his general approach to the problems of brain, mind and behavior has been hailed as pioneering and revolutionary, a definitive break from the entrenched and obscurantist traditions in early twentieth century American psychology, and a harbinger of post-1950s developments in the sciences of brain and mind.

In his history of the cognitive revolution, for example, the psychologist/historian Howard Gardner names Lashley as the iconoclast and visionary who helped to make possible the interdisciplinary project of cognitive science, a science that combined approaches from psychology, linguistics, philosophy, neurology, and artificial intelligence in order to solve the mind-body problem. By jettisoning the old-fashioned models of neural function and turning toward a

scientific explanation of higher mental processes, "Lashley helped set the stage for a cognitive science approach to behavior and thought."[7]

Likewise, in a volume celebrating the inception of neuroscience, an interdisciplinary conglomeration of neurophysiology, neuroanatomy, and neurochemistry, Lashley's name is repeatedly invoked by such luminaries in the field as Roger Sperry, Alexander Luria, Wilder Penfield, and Ralph Gerard. Lashley, they agreed, pioneered the idea that the highest and most complex mental processes could be addressed by the tools of biological science. Lashley made the "neural correlates of conscious experience" a worthy and reputable problem for science; he showed his followers that the strengths of physiological psychology could be directed toward the mysteries of thought, feeling, and memory. The neuroscientist Eliot Stellar put it most vividly when he said that Lashley had stood at the crossroads of psychology and neurology "just as the traffic was beginning to roar" and had made that intersection a natural place to stand.[8]

During his lifetime, Lashley delighted in creating myths about himself, rewriting his own history and obscuring the steps by which he reached his conclusions. According to the most tenacious of these myths, Lashley was a scientist who transcended time and place, a man without context. His science, he insisted, was motivated by no worldly concerns, but by a desire simply to understand the facts of brain function, mind, and behavior. He was, in the words of one of his admirers, a "scientist's scientist" who not only upheld but seemed actually to fulfill an ideal of purity, who pursued his research without an interest in its possible medical applications, in its social or moral value, or in its political meanings. Ultimately, he hoped, his science would be cleansed even of theoretical presuppositions.

The retrospective glorifications by the neuroscientists and by the historian Gardner, while they certainly reinforce Lashley's importance, do little to dispel this persistent myth of the man without context. Both cognitive science and neuroscience were late twentieth-century phenomena: the former began to gain momentum only by the mid-1950s; the latter was not officially founded until 1961. Neither took root and developed during Lashley's lifetime. By naming Lashley as their scientific forefather, the authors of these accounts achieve a curious feat: they place Lashley in the context of a future he could not have imagined and for the most part did not see. They perpetuate the image of the transcendent scientist by showing the great extent to which Lashley was ahead of his time, by excising him from his own early twentieth-century context and placing him in a later one. Neither of these accounts asks, or answers, the deeper

[7] Howard Gardner, *The Mind's New Science: A History of the Cognitive Revolution* (New York: Basic Books, 1985), 264.

[8] Eliot Stellar, "Physiological Psychology: A Crossroad in Neurobiology," in *The Neurosciences: Paths of Discovery*, eds. Frederic G. Worden, Judith P. Swazey, and George Adelman. (Cambridge: MIT Press, 1975), 363.

historical questions about Lashley and his work: why did he choose to do the work he did *when* he did, before it was vindicated by later approaches? Why did he decide to stand at the crossroads *before* the traffic had begun to roar?

More generally, this study asks: to what scientific and social contexts does Lashley belong? How did these contexts shape his approach to and solution of a seemingly transcendent scientific problem? To what, or to whom, in his own time and place, was he responding?

Born in 1890 and embarked on a scientific career by 1910, Karl Lashley was the heir to two different nineteenth-century scientific traditions: a neurological tradition, based in the medical clinic and devoted to the localization of mental functions in the brain; and a neurophysiological tradition, based largely in the laboratory and dedicated to the experimental study of the reflex. Lashley accepted neither of these traditions wholesale; rather, he borrowed and combined key insights from both in creating his own science. From neurology, he took the emphasis on the brain and its functions, but removed it from its clinical setting. From neurophysiology, he borrowed the centrality of the laboratory, but jettisoned the reflex concept. With this new combination of old scientific tools, Lashley set out to reform the field of psychology, to turn it from a semi-humanistic discipline into a rigorous, decisively materialistic, laboratory-centered experimental science of brain and behavior.

Of the two traditions, Lashley was more closely associated with neurology. In the nineteenth century, this science was dominated by the belief that the various mental functions were located in specific regions of the cerebral cortex; thus the tradition was often called the science of "cerebral localization." In its most familiar and often caricatured form, localization was represented by phrenology, Franz Josef Gall's attempt to find the seat in the brain of such complex mental functions as memory, reason, intellect, and will. Gall derived his conception from close anatomical, behavioral, and physiognomical studies on his fellow human beings, as well as from comparative anatomy. His idea was rapidly popularized by his followers as the notion that one's strengths and weaknesses could be divined by "reading" the bumps on one's skull.

By 1820, phrenology had begun to fall into disrepute for a variety of reasons, among them the 1824 discovery by the French physiologist Pierre Flourens that the brain actually functioned as a whole. Pursuing a unitary conception of mind, Flourens argued that the brain too must be unitary, not a mosaic of discrete capacities (an argument often considered an anticipation of Lashley's a century later).

By the 1860s, however, the localizationist theory had returned to fashion: Gall's doctrine of separable mental faculties was revived with the discovery by a French neurologist, Paul Broca, that the advanced mental faculty of "articulate language" could be precisely located in the third left frontal convolution of the cerebral cortex. Broca made this discovery through a series of famous studies of patients

with aphasia, or inability to speak, apparently brought on by damage to the center in the brain controlling expression of language.[9]

Meanwhile, other discoveries in nervous function, coming out of the neurophysiological tradition, were taking place. The physiologists Charles Bell in 1811 and François Magendie in 1822 independently discovered that sensory and motor functions could be assigned precisely to different areas of the nervous system: to the dorsal and ventral roots, respectively, of the spinal nerves. Thus the dorsal roots were responsible for identifying and classifying incoming sensations, while the ventral roots were the source of the motor responses to those sensations. In the 1830s, the work of Johannes Müller and Marshall Hall demonstrated that this connection between sensation and motion, between stimulus and response, was the actual physical basis underlying reflex behavior. The physical connection between the two types of nerves was the actual physical path along which a reflex traveled; Müller and Hall believed that these reflex arcs, coursing through the nervous system, connecting sensation with motion, were at the heart of all automatic but purposive behavior.[10]

In the latter part of the nineteenth century, the reflex concept became, in the hands of neurologists and neurophysiologists, an immensely powerful tool to sort through the complexities of nervous function. The challenge was to determine the extent of the usefulness of the reflex concept. It worked perfectly well to explain automatic or lower level behaviors, but could it be used in explaining higher mental functions as well? Everyone agreed that reflex arcs coursed through the subcortical nervous system, but how high up the spinal cord could the concept be applied? Was the cerebral cortex itself implicated in the reflex arcs? Did reflexes course through the brain? Were reflexes at the basis of mind?

A surprising number of neurophysiologists and neurologists from a diversity of national and cultural backgrounds answered this question in the affirmative, and were supported by experimental evidence. In one of the earliest expositions of the idea, the Russian physiologist Sechenov, in his 1863 work "Reflexes of the Brain," established the reflex as "the basic unit of *all* psychological functions."[11] In the 1870s, the British neurologist John Hughlings Jackson, following his teacher Thomas Laycock, as well as the British philosopher-psychologists Alexander Bain, Herbert Spencer, and G. H. Lewes, also began to turn the reflex concept to an explanation of cerebral function. The brain, Jackson theorized, was itself a sensory/motor apparatus that operated through the creation of reflex con-

[9] For a history of brain localization, see Anne Harrington, *Medicine, Mind and the Double Brain* (Princeton: Princeton University Press, 1987), and Robert M. Young, *Mind, Brain and Adaptation in the Nineteenth Century* (New York: Oxford University Press, 1970).

[10] For a history of the reflex concept, see Roger Smith, *Inhibition: History and Meaning in the Sciences of Mind and Brain* (Berkeley: University of California Press, 1992), especially chapter 3; and Franklin Fearing's 1930 classic, *Reflex Action: A Study in the History of Physiological Psychology* (Baltimore: Williams and Wilkins).

[11] Smith, 108. Emphasis in original.

nections. No ideas were innate to it; rather, complex ideas developed within it through connections, or associations, between sensations and the motor responses they produced. Jackson's belief was bolstered by an 1870 discovery by two German neurologists, Fritsch and Hitzig, that motor responses could be obtained through the electrical stimulation of certain areas of the cortex; thus there were "motor centers" in the brain. In 1873 there was further confirmation by the British neurologist David Ferrier, who, using Fritsch and Hitzig's method, discovered sensory centers in the cortex as well.[12]

Despite these successes, by the mid 1870s John Hughlings Jackson had become aware of a serious problem with the reflex conception. How was it possible to understand or explain the transition from a "lower" function, such as a reflex arc linking sensation and motion, to a "higher" mental faculty, such as the language center that Broca had identified? Jackson was faced by a gap between physiology and intellect, a gap that he ultimately decided he was unable or unwilling to bridge. He concluded that, through the laws of association, the processes of sensation and motion "somehow" produced higher level ideas. To get around having to nail down this "somehow" any more specifically, Jackson adopted a philosophy called "parallelism" that allowed his neurological work on the brain to proceed without miring it in questions about how exactly mind emerged from the nervous system. Intellect, Jackson maintained, could not really be the subject of scientific inquiry; one must operate under the assumption that it was somehow produced *"while"* the various physiological processes were occurring in the brain and nervous system. While sensation and motion were becoming associated, while reflexes were forming, simultaneously, in a parallel mental world, ideas were forming in the brain. Jackson wrote:

> I do not trouble myself about the mode of connection between mind and matter. It is enough to assume a parallelism. That along with excitation or discharges of nervous arrangements in the cerebrum, mental states occur, I of course admit; but how this is I do not inquire; indeed, so far as clinical medicine is concerned, I do not care.[13]

In 1874, Carl Wernicke, a German neurologist and student of Theodore Meynert, set out to solve the problem of Jackson's elusive "somehow": to bridge the gap between Broca's advanced faculty of articulate language and Jackson's lower sensory/motor processes. Again, he posed the question: how, exactly, did the laws of sensation and motion produce the higher powers of intellect? Following Meynert and Jackson, Wernicke accepted the idea that the brain operated on reflex principles; what was disrupted in aphasia, for example, was the "psychic

[12] Harrington, 206–210, and Young, 204–210.
[13] Quoted in Young, 208.

reflex arc necessary for the normal speech process."[14] All mental functions were made possible through such reflex connections. Then, addressing himself specifically to the problem of the gap, Wernicke theorized that what could be localized in the brain were not the complex mental functions, like "memory," "intellect," or various character traits, but much simpler sensory and motor "traces" that he envisioned as "primitive memories." These traces could be found in those brain areas directly contiguous to the sensory and motor areas. When the traces were linked together by reflex arcs, the "higher" mental functions, such as the ability to speak articulately, emerged. During the remainder of the decade, investigators building on Wernicke's conception localized a wide array of mental functions in the cortex, finding centers for reading, writing and calculation, and associating the loss of each center with a corresponding clinical deficit.[15]

Despite Wernicke's modifications to the Broca/Jackson problem, and the success he had in gaining a scientific following, he had managed only to narrow the gap, not to close it. He had still not specified how the complex mental functions emerged from associations among the primitive memory centers. Anne Harrington notes the vagueness built into Wernicke's conception: "These primitive memories . . . served as the basic units that, interacting via the fiber tracts according to the laws of 'association', gave rise (somehow) to the rich complexity of mind."[16] Wernicke had redrawn the line between physiology and intellect, but still could not explain how the one became the other. In Harrington's words, "The association thus created resulted in the birth of an 'idea' – how is not really clear – that in turn, was associated with other ideas giving rise to proper sequential thought."[17]

Thus the gap between lower functions and higher remained an inescapable feature of the reflex theory of brain and mind. As long as complex mental functions were believed to be reducible to simple elements, there would be the problem of figuring out how the simple became transformed into the complex. None of the nineteenth-century localizationists managed to solve this problem, loyal as they were to the reflex concept. How to solve or get around the problem, then, became the major challenge facing twentieth-century American investigators in the mind-brain sciences.

When Lashley took on the problem in 1920, he identified the reflex concept, which the localizationists had borrowed from neurophysiology, as the source of the difficulty. His first major break from localizationist tradition was to reject this ubiquitous and powerful concept. In doing so, he rejected the disjunction between the "lower" sensory and motor functions, with their well understood basis in biology, and the higher mental powers, which "somehow" emerged from connec-

[14] Quoted in Harrington, 72.
[15] Ibid., 73.
[16] Ibid., 72.
[17] Ibid., 73.

tions or associations among lower functions. Mind, Lashley argued, did not get built up "somehow" from reflex connections. The Broca/Jackson/Wernicke gap was the artificial outcome of a false theory; their reliance on the elusive "somehow" was a result of their antiscientific approach to mind. The higher functions need no longer be approached only by way of the lower, but could be analyzed directly by experimental investigation. They need no longer exist vaguely on the other side of an unbridgeable gap.

Second, more positively, Lashley replaced the diverse mental faculties identified by the localizationists with a singular mental quality: intelligence. Crucial to the success of his program was his construction of this term. Unlike the localizationists, Lashley did not envision intelligence as an immaterial quality that emerged from physical connections – a notion that relied on some indefinable turning of the hinge from the physical to the mental, from the physiological to the psychological. Instead, from the start Lashley defined intelligence as a mental and a biological entity that had both physiological and psychological dimensions. It could be represented not only in the behavior of an animal or a person, or in their performance on tests, but also by the physical amount of functional brain mass that they possessed. Thus intelligence was for Lashley a term that did crucial work in bringing together the mental and the physical, mind and body, psychology and neurology – realms that the nineteenth-century localizationists, whatever their intentions, had ultimately kept separate. Intelligence was a term that functioned equally well, and that was intended to function well, in all of these realms; it helped Lashley to demonstrate the fundamental impossibility of holding spirit separate from matter. Moreover, in choosing the term, Lashley assigned a specific technical meaning to, and devised specific scientific measures for, a word that was already familiar to the layperson, that already had conventional social meanings and connotations.

With the rejection of the reflex concept and the reification of intelligence, Lashley fundamentally revised the nineteenth-century parameters of the mind-body problem. Parallelism, the belief in the separateness of the physical and the mental, the ultimate recourse of nineteenth-century neurologists and neurophysiologists alike, was simply not an acceptable answer for him. It was a cure worse than the disease: not a solution to the problem, but the admission of a deep and abiding ignorance. The only possible answer, Lashley believed, was a thoroughly materialistic one: everything in the world, including mind, was essentially the interactions of matter. There was no room in his science for an immaterial intellect, or even for the idea that thought somehow "emerged" from the brain.

Though he parted ways conceptually from the nineteenth-century neurologists and neurophysiologists, methodologically Lashley remained much in their debt. The method that he spent almost four decades developing and perfecting was an eclectic mixture of the two nineteenth-century traditions. From his teacher Shepherd Ivory Franz (who was himself a student of the localizationists), Lashley

borrowed the method of cortical ablation, in which different areas of the cerebral cortex are systematically destroyed and the effect on behavior assessed. But while the localizationists, being mainly clinicians, used human beings as their subjects and therefore had to wait until nature or some misfortune produced someone with a damaged brain, Lashley, now following the neurophysiologists, used animals – almost exclusively rats – as subjects, and thus could control the area and extent of brain lesions himself. Like the Russian physiologists Sechenov and Pavlov (whose influence in particular came to him through his teacher John B. Watson), Lashley removed the site of his science from the medical clinic and located it firmly in the laboratory.

With these methodological resources – the use of cerebral ablation, the emphasis on animals, the centrality of the laboratory – held in place by a thoroughgoing materialism, Lashley built a science he called neuropsychology.[18] Its purpose was to reveal the relationship between brain function and behavior, particularly intelligent behavior, in rats, though its results could be extrapolated to higher species, including humans. The method on which it rested was simple in conception, though over the course of a forty-year career, Lashley elaborated it to tremendous proportions. First, he ablated a portion of the rat's cerebral cortex. Then, after giving the rat a chance to recover from the operation, he tested its ability to learn or remember a series of tasks, such as running a maze, distinguishing between two patterns, or tripping the lever on a specially designed "problem box."

Lashley found, much to his surprise, that the rats, despite missing parts of their brains, did not lose their ability to function intelligently, and that in fact up to 50 percent of the cortex could be extirpated before learning and memory became severely impaired. He concluded from his experiments that function was not localized in discrete portions of the brain, that ideas and memories were not stored in single cells like jewels in individual jewel cases; rather, function was distributed throughout the brain. Lashley summarized his findings in two principles that have become synonymous with his name: equipotentiality, that all parts of the brain are capable of carrying out all functions; and mass action, that only a certain amount of brain is necessary to ensure normal function.

Though Lashley derived the methods and strategies of his own science mainly from traditions in neurology and neurophysiology, he never associated himself professionally with those disciplines. Rather, his professional allegiance was al-

[18] Today the term "neuropsychology" signifies a branch of psychiatry that locates the source of mental disorders in brain lesions. While the mind-brain correlation clearly owes something to Lashley's science, the clinical application was utterly foreign to his perspective. To understand the meaning of Lashley's neuropsychology, we must cleanse the term of its modern connotations. For Lashley, neuropsychology was intended to illuminate the functions of the *normal* brain. For a history of the term and Lashley's use of it, see Darryl Bruce, "On the Origin of the Term 'Neuropsychology,'" *Neuropsychologia* 23.6 (1985): 813–14.