

Neuroscience and the Soul:

The Dualism of John Carew Eccles

By J. Allan Hobson

April 01, 2004

Although it was not always so, today the investigation of the relationship between the brain and the mind—the “problem of consciousness” —is reckoned by many to be neuroscience’s ultimate question. What happens, then, when a brain scientist, a consummate investigator awarded the 1963 Nobel Prize in Physiology or Medicine, comes to the brain-mind question with an unshakable faith in what the answer must be? Will science and the experimental method prevail? This is the question raised by the career of Australian-born physiologist John Carew Eccles, who grew up in a religious tradition that dictated faith in an immaterial, immortal mind and spirit. Several times, Eccles’s path crossed that of Harvard University researcher J. Allan Hobson, whose discoveries about sleep and dreaming clashed head-on with belief in a mind that exists independent of the brain. Hobson reflects on the wider implications that this conflict may have for neuroscientists as they go about their work. *Cerebrum* will welcome, for its letters section, comments up to 500 words on any of the issues raised here.

Scientific knowledge is often at odds with religious belief. An obvious and problematic conflict is between the Darwinian theory of natural selection and the Bible’s account of creation. Here, the doctrinal clash is sharp and clear-cut. Darwinian theory’s threat to religious belief was immediately perceived, leading in 1860 to fierce debates between the Anglican bishop Samuel Wilberforce and the English biologist Thomas H. Huxley. For his performance in those and other encounters, Huxley became known as “Darwin’s Bulldog.” A century and a half later, tension still runs high, as creationists seek equal time with evolutionists in teaching U.S. public school children.

A conflict not yet public or political, but potentially even more contentious and far-reaching, arises in the investigation of the brain basis of human consciousness. As consciousness is increasingly well explained in neurobiological terms, objections are sure to be offered by those whose religious beliefs include the divine origin, nature, and destiny of the human soul. In philosophical terms, this conflict is expressed as the debate between monists, who hold that all human experience and awareness, including our spiritual longings, are brain based, and dualists, who hold that our spirits are God-given and, while usually operating in harmony with the brain, are separable from it. At stake here is nothing less than how we conceive our ultimate fate. For the monist, the death of the brain is the final and complete end of the person. For the dualist, life after death is possible. There are, as always, intermediate positions, but they only serve to blur the essential issue raised by the extremes.

As a rule, scientists try to keep their experimental work separate from whatever religious beliefs they hold. But what happens when the distinction between science and faith becomes blurred, leading to a confrontation between divergent views of human origin and fate? The issue and its implications are raised

in dramatic, sometimes provocative, fashion by the life and career of John Carew Eccles. As Christof Koch asserts in *The Quest for Consciousness: A Neurobiological Approach*: “The most famous modern defenders of dualism are the philosopher Karl Popper and the neurophysiologist and Nobel laureate John Eccles.”<sup>1</sup>

Although Eccles’s views of consciousness were embraced by few scientists, he is credited with having had a scientific interest in the problem of consciousness at a time when most of his colleagues ignored it. This article examines how Eccles’s dualism influenced his thinking about the brain and suggests that the conflict between brain science and dualism may become more acute as progress is made in this still-difficult area of research.

For Eccles, as for such famous scientists as Sir Charles S. Sherrington and Santiago Ramón y Cajal before him, mind and brain were radically different entities. Seeing spirit as part of mind, these giants of modern neuroscience were committed to the notions of the transcendence and immortality of the soul, two postulates that most scientists believe are incompatible with evidence- and logic-based science. Eccles was a great scientist, but his most fundamental views of the world were rooted in faith, and, as a consequence, he ignored discoveries in neuroscience that challenged dualism. Some telling examples of these advances come from my own field, the neurobiology of sleep and dreaming, which offers a relevant subset of mind-brain and consciousness problems.

#### A LIFE IN BRAIN SCIENCE

Eccles’s life neatly spans the 20th century. His Nobel biography, <sup>2</sup> on which I lean for this brief sketch, reports that he was born in Melbourne, Australia, on January 27, 1903, and graduated from Melbourne University with first-class honors in medicine. As a Victorian Rhodes Scholar, he entered Magdalen College, Oxford, in 1925. Awarded first-class honors in natural science in 1927, Eccles became research assistant to Sherrington, studying reflexes and publishing eight papers with him. Fast forwarding to a story I will tell later, it is notable that the first successful recording of the human EEG was reported in 1928.

In 1929, Eccles was awarded an Oxford D. Phil. degree for his thesis on neural excitation and inhibition. He later held a series of appointments at Oxford. During this period, he studied synaptic transmission in the central and peripheral nervous systems, using new techniques of electrophysiology, such as amplifiers and cathode ray oscilloscopes. This was a period of controversy between exponents of rival chemical and electrical theories of synaptic transmission, and Eccles resisted many aspects of the chemical transmitter theory that would eventually become accepted.

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In 1937, Eccles returned to Australia to direct a small medical research unit at Sydney Hospital and, from 1937 to 1943, focused on electrophysiologic analysis of the neuromuscular junctions of cats and frogs. He

became professor of physiology at the University of Otago, New Zealand, in 1944, where he returned to the study of synaptic transmission in the central nervous system. In 1951, he and his colleagues succeeded for the first time in inserting microelectrodes into nerve cells of the central nervous system and recording the electrical responses produced by excitatory and inhibitory synapses. While in New Zealand, Eccles met the philosopher Karl Popper, from whom he learned what is called the “logical positivist philosophy” of the scientist’s relationship to his hypotheses, including the idea that all hypotheses must be susceptible to rigorous testing but at most can be proven false (in whole or in part), never confirmed with finality. The Nobel biography reports Eccles’s view that positivism freed him as a scientist to “rejoice even in the falsification of a cherished theory, because even this is a scientific success.”

Moving to the Australian National University, where he remained from 1952 to 1966, Eccles concentrated on the biophysical properties of synaptic transmission, work that eventually garnered him the Nobel Prize. He organized energetic square dance parties at his homes in Sydney and Canberra, and there fostered marital unions between three European colleagues and three young Australian Catholic women. Those colleagues, Steven Kuffler, Paul Fatt, and Bernard Katz, helped Eccles establish his reputation as a world leader in cellular neurobiology and earn a richly deserved share in the Nobel Prize. In turn, Eccles trained them and other students, including Rudolfo Llinás, as future leaders in the flowering of 20th-century neuroscience.

#### ECCLES THE DUALIST

In 1951, Eccles published a now-famous essay in *Nature* on “Hypotheses Relating to the Brain-Mind Problem.” To his lasting credit, he asserted that the purpose of his article was to specify and test the hypotheses that arise from the dualistic position, writing that:

The Cartesian dualism of mind and matter necessarily involved the problem of how mind and brain could interact in perception and in willed acts. Most philosophers now argue that the hopeless difficulties of this problem have rendered untenable both dualism and the interactionist view of brain-mind liaison. On the other hand, many men of science find in dualism and interaction the most acceptable initial postulates in a scientific approach to the problem of mind and brain. In such an approach the question arises: What scientific hypotheses may be formulated that bear in any way on the hitherto refractory problem of brain-mind liaison?

Eccles hypothesized that the liaison of brain and mind occurred only in the cerebral cortex, when that part of the brain was activated. In particular, he ascribed dreaming to “bursts of activity in the electroencephalogram,” as if he believed (as I do) that dreaming was a kind of consciousness. Eccles also held that every perceptual experience was a function of a specific pattern of neuronal activation and that memory was caused by an increase in synaptic efficacy. Given these reasonable assumptions, it is difficult now to see why Eccles felt that experience and memory were “unassimilable into the matter-energy system.” Because of this conclusion, he felt it useful—and even necessary—to postulate that the activated cortex had “a sensitivity of a different kind from any physical instrument” and that “mind achieves liaison with the brain by exerting spatio-temporal fields of influence that become effective through this unique...function of the active cerebral cortex.” But to the monist, a simpler and more elegant explanation is that subjective awareness is an intrinsic, emergent aspect of brain activation.

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To justify his hypotheses, it was necessary for Eccles to assume that contemporary physics could not detect, measure, or predict the supposed mental forces. In his Nature essay, he suggested that, while waiting for physics to improve, we should take note of “well-controlled experiments that give evidence that there is a two-way traffic between mind and the matter-energy system,” and went on to assert that “psychokinetic experiments leave little doubt that very slight changes can be produced by some minds on moving physical objects such as dice.” To support his hypothesis of nonphysical causation, Eccles also added the claims of extrasensory perception (ESP).<sup>3</sup> In retrospect, these arguments seem weak; well-controlled experiments with ESP have repeatedly failed to support the claims of its exponents.

#### AWKWARD EVIDENCE FROM SLEEP RESEARCH

In 1963, the same year that Eccles won the Nobel Prize, an up-and-coming brain scientist, Rodolfo Llinás, arrived at the Australian National University to begin work on his Ph.D. thesis. The first thing Eccles asked him during his initial interview was, “Do you believe in psychokinesis?” In other words, did Llinás think that mental activity was capable of having effects at a distance, as Eccles had suggested in Nature? This was exactly the question that C. C. Jung put to Sigmund Freud in a conversation, famous in psychoanalytic circles, during which Jung was convinced the furniture in Freud’s office had moved under the influence of some non-physical power. Jung, the son of a Protestant preacher, believed in psychokinesis; Freud, the atheist, did not. We know that Eccles believed in psychokinesis and, as a practicing Roman Catholic, certainly believed in mystery and miracles.

From the 1920s through 1960s, when Eccles performed his remarkable research on the biology of nerve cells, other scientists made long strides in understanding the neurophysiology of mind. Their discoveries would eventually confront Eccles with uncomfortable evidence of the brain basis of consciousness—evidence that Eccles would ignore or reject despite his avowed interest in that topic.

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In 1928, Hans Berger pioneered the electroencephalogram (EEG), a recording of electrical impulses from the head. By 1932, he had convinced even skeptics such as Edgar Adrian that the voltage changes recorded from the human scalp originated in the brain, not the scalp muscles, because the changes correlated with sleep and waking. By 1936, other neuroscientists reported that the sleep EEG changed periodically from high voltage/slow to low voltage/fast every 90 minutes. Eccles, of course, was aware of this work, which set the stage for Eugene Aserinsky and Nathaniel Kleitman’s 1953 discovery of rapid eye movement (REM) sleep and its correlation with dreaming. Coming on top of earlier discoveries, the

discoveries about REM sleep called for a new brain-state paradigm, one that would complement, but go far beyond, the doctrine of reflexes that had so successfully guided Eccles's work.

It should be emphasized that both Eccles's Oxford mentor Sherrington and the Russian experimental psychologist Ivan Pavlov believed that sleep was caused by a cessation of brain activity when there was a drop in external stimuli. None of these great scientists anticipated the remarkable paradigm shift that would accompany recognition that the brain never turns off, that its activation is largely independent of stimulus drive, and that "offline" auto-activation of the brain in sleep results in the conscious experience of dreaming.

Taken together, these discoveries, accumulating over several decades, constituted virtually inescapable evidence that consciousness is an intrinsic function of the brain and inseparable from it. That Eccles ignored these advances, or failed to see their challenge to his dualism, was brought home to me when I attended his 1966 lecture on "The Cerebellum as a Neuronal Machine" at Harvard Medical School. I was as shocked as everyone else in the audience when Steven Kuffler introduced Eccles as the individual who had "made more mistakes than any other neurophysiologist." After a long and agonizing pause, Kuffler added that Eccles had also gotten more things right.

By the time of this lecture, Eccles had become interested in the organizational aspects of the brain, including the dorsal columns, thalamus, hippocampus, and cerebellum. Given this interest, one would expect Eccles to be knowledgeable about important discoveries from sleep research, such as the inhibition of the spinal cord motor neurons that renders them unresponsive to excitatory stimuli during REM sleep. The important implication of this work was that reflex spinal activity, so carefully studied by Sherrington and Eccles, was as dependent upon brain state (sleep or waking) as was consciousness itself. In fact, motor-neuronal inhibition is the basis for the paralysis that prevents us from moving during even our most animated dreams.

In 1965, I had presented my work on hypothalamic lesions at the Tokyo Physiological Conference, in a sleep session chaired by none other than Eccles. I was surprised, and a bit hurt, at how little interest Eccles took in the evidence that sleep—and, by implication, dreaming—was actively controlled by the brain. At that time, however, I did not know he was a dualist. During the question period after his 1966 Harvard lecture, therefore, I asked Eccles to comment on the significance of the sleep-dependent inhibition of spinal reflex activity. To my astonishment, which continues to this day, Eccles went to the blackboard and drew this diagram:

Then he said, "In sleep, the mind is disconnected from the body." Cartesian dualism was obviously alive and well in the brain-mind of J.C. Eccles!

THE FAITHFUL FALSIFIER

Eccles's revealing performance at the Harvard lecture started me thinking that even great intellects like Sherrington, Cajal, and Pavlov might be unable to distinguish clearly between their religious beliefs and their scientific philosophies. No one knows exactly how widespread this conflict may be among scientists, but one intriguing bit of evidence is available. During my active teaching days at Harvard, in the early 1980s, I met Jeffrey Saver, a medical student. After graduating from Harvard College, Saver used a Sheldon Traveling Fellowship to interview scientists around the world about their religious beliefs. He found that, on Sundays, the vast majority of them embraced convictions that were completely incompatible with their Monday-through-Friday scientific principles.

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Eccles's friendship with the philosopher of science, Karl Popper, is also worth a few more comments because of Popper's fame as a proponent of rigorous hypothesis testing. As previously mentioned, Eccles was a strong adherent of the electrical theory of neural transmission and, as such, an opponent of the soon-to-be prevailing chemical model. When his intracellular recording experiments produced unequivocal evidence in favor of the chemical theory, Eccles was at first upset. He was comforted by Popper, who praised him for the most essential scientific achievement: the falsification of a hypothesis. Eccles's pride was preserved, and he and Popper became lifelong friends and collaborators.

Eccles had a long friendship and collaboration with the philosopher of science Karl Popper. Together they wrote *The Self and Its Brain*, published in 1977.

One product of this relationship was Eccles's philosophical book, *Facing Reality*, published in 1970. Another was the book that he and Popper wrote together, *The Self and Its Brain* (1977). The title suggests that both Eccles and Popper believed in something more than material causality. But even Eccles and Popper's third (or social) world, including written words, can be fully described in terms of information. Because all information enters the nervous system as a physical stimulus, it follows that, to enter or arise from a brain, information must also be physicalized. As I read or write, the words are rendered by my visual brain or the motor cortex, and my writing hand, as physical objects. The meaning that arises from them or the associations they inspire are all emergent properties of my brain. There is no requirement for dualism in accounting for sentience, the sense of self, or the written word. Materialism is sufficient.

Eccles, however, could not accept that the defining characteristic of the brain-mind is its intrinsic capacity for information processing. He introduced extra-physical forces, which he called the "vis externa," to act on the brain to cause mental life and zeroed in on specific neurons (more precisely, the apical dendrites of cortical neurons) as the sensors of his putative external force. This hypothesis (and the implied quest for a demonstrable link between God and man) echoed the work of Emanuel Swedenborg, the 17th-century

natural scientist, philosopher, and mystic who thought he would see God if only his microscope were sufficiently powerful. Indeed, so successful was the microscopic paradigm that it still beguiles some scientists, who think they will find a consciousness widget in some sub-cellular neural gadget.

When Swedenborg failed to find God at the end of his microscope, he turned to more meditative methods. In particular, he learned to intensify his dreams by sleep deprivation. The natural result of sleep deprivation is called a “REM rebound.” After losing REM sleep, we normally pay back the debt by longer, and stronger, REM periods. Dreaming duration and intensity then increase. In due course, Swedenborg experienced one of these rebounds, in which he said he met God’s angels in person and received from them instructions for the founding of the Church of the New Jerusalem. Interpreted through the lens of modern neuroscience, the Swedenborg story confirms that no *vis externa* is necessary to account even for this apparently miraculous revelation. It is sufficient to tilt the brain’s own REM sleep system in the direction of hallucinatory overdrive in which people can meet whomever they want and accomplish whatever bit of carnal or spiritual business appeals to them.

#### THE ANTAGONISM OF FAITH AND SCIENCE

I saw Eccles for the last time in 1969, at the first meeting of the new Society for Neuroscience in Washington, DC. At age 66, he was still a bundle of energy. I have a vivid recollection of him walking rapidly up and down the corridors, basking in his fame and celebrity.

At that same meeting, Vernon Mountcastle told me about Floyd Bloom’s work on the brain’s locus coeruleus. “There’s a brain within the brain,” said Mountcastle, meaning that the control of consciousness could at last be assigned a chemically specific neuronal mechanism. The full import of Mountcastle’s statement did not hit me until 1975, when Peter Wyzinski, Robert McCarley, and I showed that the metronome-like firing pattern of locus coeruleus neurons that occur in waking give way to sporadic discharge in non-REM sleep and to a complete cessation of firing in REM sleep. This same REM-off property is shared by other chemically coded modulatory neurons, the serotonergic and histaminergic neurons of the brain stem. We proposed that it was these changes in chemical activity in the brain that determined the difference between dreaming and waking consciousness. It was clear that the mind was not separated from the body in sleep, as Eccles had claimed only 10 years earlier. The mind just changed its conscious state as the brain changed its neuronal firing pattern—a conclusion amply supported by recent brain-imaging findings.

Now no reasonable doubt exists that we sleep because the brain changes its state, and we dream when that change in state assumes certain physiological dimensions. The consequences are both profound and far-reaching for science as well as for religion. All available evidence is that consciousness, including what we might call spirit or soul, is a brain function. Presumably, die-hard dualists, like Eccles, could still retreat to the position of René Descartes, insisting that the relationship of mind and brain we observe in every instance is best understood as two perfectly synchronized watches set in parallel motion by God and evidencing God’s remarkable creative powers. The problem is that no evidence whatsoever exists to favor this hypothesis over the integrationist view that mind and brain are two levels of a unified system.

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What does the Eccles story tell us? On the positive side, it says that great science can be done by people who have strong religious beliefs. The human mind is a many splendored thing, whose multiple compartments can contain isolated and internally incompatible ideas—although, as I believe I have suggested, at the risk of short-circuiting the free flow of thought. Eccles's story tells us, too, that scientific evidence alone can never overcome assumptions based on faith, simply because faith is a claim to a nonsensory, nonrational form of knowledge and, therefore, explicitly insulated from scientific evidence and the claims of reason. In the end, when facts contradict our cherished beliefs, each of us decides, with only intellectual honesty to guide us, whether our beliefs or the facts are dispensable.