

Eccles' perspective of the forebrain, its role in skilled movements, and the mind–brain problem

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Abstract

Sir John Eccles' experimental life evolved from the “bottom” up: the synapse to the modular circuitry of the spinal cord, later the cerebellum and, less extensively, also the thalamus and hippocampus. He experimented quantitatively on basic properties of cell membranes, synapses, transmitters, cellular modules, reflexes, and plasticity. In parallel, he was also motivated to consider philosophical problems of mind–brain interactions. It was mostly during Eccles' “Swiss period” (1976–1997) that new experimental work advanced understanding of *intentional motor actions and their preparation*. For example, early brain imaging work suggested that the so-called “supplementary” motor area was rather a “supramotor” area, concerned with intentional preparation to move. Eccles also closely followed work on cortico-cerebellar integration and learning. His final contribution, in collaboration with the quantum physicist, Friedrich Beck, was a model of how specific neuronal modules interact with the mind. Being a declared dualist, Eccles encountered considerable resistance and skepticism among neuroscientists in accepting his experimentally untestable mind–brain theories. But one can only admire the remarkable continuity of effort in his search for modular operations of identified neurons in the central nervous system and their synaptic actions. This effort was facilitated by collaboration with the eminent anatomist, János Szentágothai, who had previously helped Eccles advance understanding of spinal and cerebellar circuitry. This review also includes some personal views on current understanding of the forebrain, with an emphasis on the multiplicity of cortical modules, all of which contribute in the mental preparation for forthcoming intentional actions.

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Abbreviations: CNS, central nervous system; SMA, supplementary motor area

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1. Introductory remarks

I first met Sir John Eccles (1903–1997) in 1963 at a Summer School of Brain Research that took place in Amsterdam, The Netherlands. At that time, I was with Fritz Buchthal (1907–2003) at his Neurofysiologisk Institut in Copenhagen, Denmark. In collaboration with an American visitor, Michael Gassel, I had recently demonstrated that the “F-wave” (used in clinical nerve conduction studies) had two components, a spinal reflex and a recurrent excitation of motoneurons via antidromic propagation (Gassel and Wiesendanger, 1963). While drinking coffee after lunch, Eccles came to our table and asked me what kind of work I was doing. As I started to tell him about the F-wave, I was amazed and greatly flattered by his interest and encouragement. It was a profound experience about the value of a collaborative attitude in science. Subsequently, I had frequent encounters and discussions with Eccles during his later, 1960s’ visits to the Brain Research Institute in Zurich. Next, in the early 1970s, while I was with the University of Western Ontario in London, Canada, regular friendly meetings of a small group were arranged by Eccles in nearby Buffalo, USA. In 1976, 1 year after my return from Canada to the University of Fribourg in Switzerland, Eccles retired from experimental work and moved to Switzerland (see Stuart and Pierce, 2006). We had frequent personal contacts when he visited Fribourg (Fig. 1) and other Swiss universities, as well as by hand-written letters and telephone calls. During these various interactions, Eccles always provided lively questioning and discussion. Sometimes, he lectured to medical students and the faculty at my and other Swiss universities. He was also invited to discussion sessions by the Department of Philosophy at the University of Fribourg.

Eccles asked me to help him in the organization of two memorable international meetings. The first was a 7-day, 1983 conference on “Cerebral Events in Voluntary Movements: the Supplementary Motor and Premotor Areas”, which took place nearby Munich at Castle Ringberg of the Max-Planck Society. Eccles and Otto Detlev Creutzfeldt (1927–1992, member of the above Society) were the principal organizers; Christoph Fromm and myself contributed mainly with practical preparations (Creutzfeldt et al., 1985). The second (also 7-day) conference was on “The Principles of Design and Operation of the Brain”. It took place in 1988 at the Pontifica Academia Scientiarum of the Vatican in Rome, Italy (Eccles and Creutzfeldt, 1990). Leading investigators on action initiation and higher brain function were invited, including several of Eccles’ past collaborators: Per Andersen, Vernon Brooks, Masao Ito, Ben Libet, and János Szentágothai (1912–1994).

In 1993, an international gathering in Frankfurt, Germany celebrated Eccles’ 90th birthday. It was attended by most of his previous collaborators. After that meeting, a small gathering of Swiss physiologists had also been planned to honor his

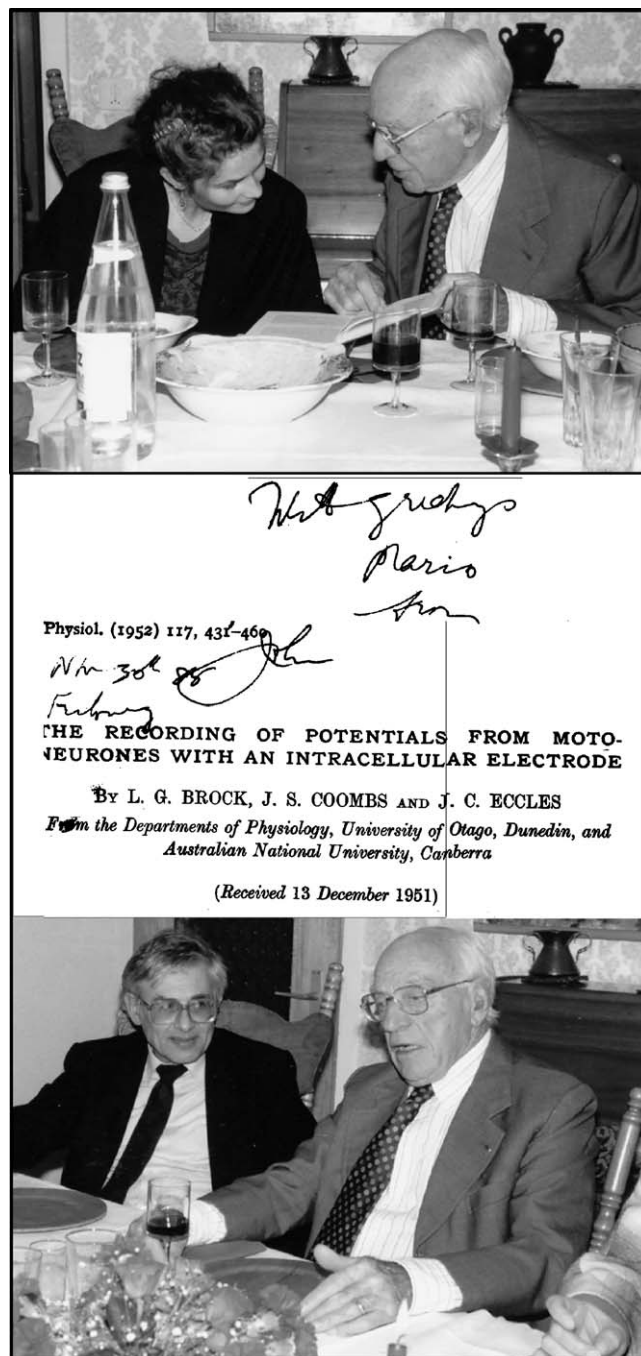


Fig. 1. A typical interaction with Eccles. He received many distinctions, including the Doctor honoris causa of the Faculty of Science, University of Fribourg. In one of his later visits to Fribourg in 1988, he gave a lecture to a group of students. After dinner at our home, he explained some points from one of his books to a psychology student (my daughter). He signed an original Journal of Physiology reprint (Brock et al., 1952), which I had in my collection. This seminal work, which helped pave the way for Eccles’ 1963 Nobel Prize, described the intracellular recording of synaptic potentials in motoneurons of the spinal cord (see also Brownstone, 2006).

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