Corticospinal control of movement

Corticospinal Neurones: Their Role in Movement. By C. G. Phillips and R. Porter. Pp. 450. (Academic: London and New York, 1977.) $32; £16.80.

THE cortical motor area was discovered by Fritsch and Hitzig in 1870. Its axons used to be thought of as providing a straightforward passageway, the pyramidal tract, to the spinal segments, but one without exclusive right to engage the executives of Sherrington's final common pathway, today's alpha motoneurones. The Nauta stain in the hands of Kuypers (Rotterdam) has revealed a surprising wealth of emissions from the axons along this tract (as shown in his excellent diagram). For the cells in the cortical motor area whose axons branch off in the internal capsule, the cerebral peduncles and the pon s the authors of the book reviewed here introduce the term "parapyramidal"; Starlinger's old term "extrapyramidal" is reserved for neurones located outside the area of origin of the pyramidal tract. The main aim of this book is to analyse and summarise what is known about the anatomy and physiology of the corticospinal neurones and the pyramidal tract.

An attractive feature of the work is that the authors repeatedly return to a discussion of the history of their subject matter before proceeding to descriptions of experiments using microelectrodes on single cells at rest and in activity, of microanatomy, and so on. Room has been found for every contribution of interest and most leading experiments have been closely scrutinised to sort out hard evidence from hypotheses and notions.

Both authors have made decisive contributions to cortical motor physiology. Phillips was in fact pioneering cortical microphysiology in the mid-1950s, making intracellular recordings from the large Betz cells of the cortical motor area. His major achievement (working with a large team of coworkers) has been the function and has provided into the function and organisation of corticospinal control in primates, which he has built up from studies of identified pyramidal tract neurones acting on motoneurones impaled for intracellular analysis. One of his coworkers was Porter, who, after returning to Monash University, returned to experiments on cortical cells in freely moving monkeys, adding new aspects to the pioneer studies of Evarts at the National Institutes of Health in Bethesda, Maryland, and of Brooks in London, Ontario, on monkeys trained to execute arm and hand movements against controlled forces.

The authors state that they have attempted to follow four main avenues for discussion: effects of electrical stimulation of the brain; the mapping of the cortical neural connexions, including a full survey of all the methods used, anatomical as well as physiological; electrical recording of neural activity during specific performances; and description and analysis of normal performance and of the effects of central and peripheral disturbances upon it. They have managed to achieve this and a great deal more. Their presentation is stuffed with well-digested information; here, I can only try to indicate what kind of organisational and functional role for the corticospinal neurones in movement emerges from their analysis of classical and contemporary experimentation.

By far the most important contributions have come from electrophysiological methods of stimulation and intracellular recording. These receive the lion's share of the authors' attention. The cortical motor area has always been held to represent a map of the body musculature. On this area, the muscles are projected in an orderly manner, and those which perform discrete, delicate movements (like the hand and finger muscles) occupy far more space (and therefore more cortical neurones) than others of less importance in this respect. The combination of muscle actions in numerous ways during activity is made possible by the fractionation of the motor area into overlapping groups or "colonies" of cortical cells projecting to the same spinal motoneurones. The projections of corticospinal axons form efficient synapses, capable of high frequency response, on spinal motoneurones. The same cells also receive a monosynaptic input of slightly different character from the muscle spindles. When in voluntary movement the gamma motoneurones for the spindles are coactivated with the alpha motoneurones, the latter are boosted through the gamma loop. Together the two routes of activation form a control system available for rapid specific action during delicate movements such as the precision grip of the primates. Lower mammals do not possess the monosynaptic variety of corticospinal contact with motoneurones, and therefore do not have the precision grip.

The small neurones of the motor area are spontaneously active but their activity is modulated less during body movement than that of the larger ones, whose axons have high conduction velocity. These latter fire repetitively to determine the extent and rate of change in the forces involved in body movement; their activity can also be modified by external stimuli in the form of instructions to the animal, even when the latter take effect by a delayed afferent trigger signal. Forces involved in voluntary body movement elicit stretch reflexes, the secondary component of which have a latency compatible with conduction through a transcortical loop.

This book will be for some time to come an indispensable companion for all those seriously interested in how the brain works and in the limits of our present knowledge in the field of motor control.

Ragnar Granit

Ragnar Granit is at the Nobel Institute for Neurophysiology, Karolinska Institutet, Stockholm.