

# Neural Control of Movement

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To my daughter Sophie Ferrell

## FOREWORD

Presented with a choice of evils, most would prefer to be blinded rather than to be unable to move, immobilized in the late stages of Parkinson's disease. Yet in everyday life, as in Neuroscience, vision holds the centre of the stage. The conscious psyche watches a private TV show all day long, while the motor system is left to get on with it "out of sight and out of mind." Motor skills are worshipped at all levels of society, whether in golf, tennis, soccer, athletics or in musical performance; meanwhile the subconscious machinery is ignored. But scientifically there is steady advance on a wide front, as we are reminded here, from the reversal of the reflexes of the stick insects to the site of motor learning in the human cerebral cortex. As in the rest of Physiology, evolution has preserved that which has already worked well; thus general principles can often be best discerned in lower animals.

No one scientist can be personally involved at all levels of analysis, but especially for the motor system a narrow view is doomed from the outset. Interaction is all; the spinal cord has surrendered its autonomy to the brain, but the brain can only control the limbs by talking to the spinal cord in a language that it can understand, determined by its pre-existing circuitry; and both receive a continuous stream of feedback from the periphery. Progress is slow in terms of the standards set by Molecular Biology, partly because many of the individual "facts" of neurophysiology only gain useful meaning when they can be put in a wider setting; in contrast, the mapping of one more gene and the determination of its base sequence is a thing in itself, available for immediate practical use. Quite apart from simple intellectual interest, each of us must periodically forsake the compelling immediacy of our own experimentation to take the wider look; failing this, what we all do risks sinking into oblivion, temporarily cited by a few other specialists who share the same jargon but never integrated into a meaningful context. Thus students of the motor system, whatever their particular interests, should both listen to each other and write for each other, and not just relate to their immediate colleagues. And, in fact, our record is good; we are relatively few, we personally do our own experiments, we remain in our chosen area long enough to get to know each other, and our type of work rarely leads to the cut-throat competition found in too many other fields.

Such thoughts may well have been in the mind of the organizers of the 32nd Congress of the Union of Physiological Sciences, held in Glasgow in August, 1993. At any rate, they set aside five full days for the five consecutive symposia on the Motor System, ranging from Comparative Physiology through Proprioception and the Spinal Cord to Cortical Control and Motor Learning. Each symposium was orchestrated by experts in the area, who chose both the speakers and their topics, and then usually led the discussion. The second day honoured the memory of Ian Boyd who had given his life to Glasgow and to the muscle spindle, and who had been instrumental in bringing the Congress to Glasgow. If he had not been suddenly cut down at the age of 60, he would surely have told us something new; he was as active as ever, and with his unique expertise the loss of his continuing contribution is irreplaceable.

As one who sat through the meetings with enjoyment, I can report that the intellectual banquet was overwhelming in both quantity and quality. One problem was that there was practically no time to view and discuss the accompanying posters, though much could be done by avoiding eating. Attendance was good throughout, aided by a wet, windy, and cold Scottish summer. Another problem was the impossibility of taking adequate notes and remembering all that one would wish to remember (an advantage of continuing to teach as one ages is the repeated demonstration that the young suffer similarly). This book with its series of articles on a variety of topics by a variety of speakers should help refresh the memory of those who attended; more importantly, it gives those who were not present an outline of what went on. Thus it should help everybody achieve an overview. But any such

book provides only a partial summary and cannot reproduce the experience of attending. For one, the illustrations are inevitably only a carefully selected sub-set of the slides presented at the time. In the present book, there is also selection of the topics included among those presented. All were asked to contribute, but only some responded. Many of those who refused will have had the best of reasons; repeated publication of the same material helps nobody. Those who have written include the energetic and organized, and those with a message that they wish us to hear. They have provided a wealth of material which we can all be grateful for having brought together under a single cover.

Peter B. C. Matthews

## PREFACE

This book, entitled "Neural Control of Movement", came about as a result of a series of five symposia on motor control which were held as part of the 32nd Congress of the International Union of Physiological Sciences (IUPS), held in Glasgow, Scotland, August 1-5, 1993. Bringing the Congress to Glasgow was the brainchild of Ian Boyd, Buchanan Professor of Physiology at the University of Glasgow, who sadly died in 1987 and was not able to see the results of all his efforts. A key organizational feature was to bring all the satellite symposia into the Congress under particular themes. Under the theme of Motor Control, five symposia were held on consecutive days, covering a broad range of topics and preparations from *Crustacea* to man. We were privileged to be asked by the IUPS Programme Committee to organize a symposium in honour of Ian Boyd entitled "The Ian Boyd Symposium." Early on during the planning of this symposium we had agreed that we would choose our speakers under two broad headings: "Sensory receptors" and "Proprioception" and we would allocate approximately equal time to each of these areas. Since the time available for the symposium was very limited, we were able to select only five speakers for each of the two sessions. We both found it difficult to select such a small number of key speakers from the many international contributors currently active in these fields. Inevitably, we were criticized for having made important omissions in our programme. As a result we decided that one way of at least partially redeeming ourselves, as well as doing the subject more justice in terms of the coverage of topics was to try to publish the proceedings of the meeting. We therefore called for manuscripts from our speakers as well as from other colleagues who attended the symposium and who we had been unable to include on the programme. Another important motive for publication was to commemorate the Ian Boyd Symposium, and grasp the opportunity of having so many distinguished researchers in motor control gathered at one site, at the same time. We therefore asked speakers at the other four symposia to contribute manuscripts as well. The response to our call was sufficient to make this book a reality and we are very grateful to those who gave of their time to contribute manuscripts.

As the manuscripts came in, it soon became clear that they fell within one of several clearly defined areas. It led us to include a number of section headings - "Afferent Mechanisms," "Proprioception," "Reflexes," "Locomotion," "Development," "Cerebellar Mechanisms" and "Comparative Studies." Inevitably, any classification of this kind is somewhat arbitrary and a number of manuscripts covered more than one area. Nevertheless, since this is a book concerned with broad areas of motor control, such headings are, in our view, useful to the reader.

Scrutiny of the range of topics covered reveals that as well as a surprising amount of activity in traditional areas such as "Afferent Mechanisms" and "Reflexes", there is a great deal of work currently going on in "Proprioception," "Locomotion," and "Development." One of the important steps forward in the field reported at the symposium and represented here is the concept of phase of locomotion dependent changes in reflex action of muscle receptors. This integrative approach, involving three different areas, points the way for future progress in the field. Here, too, the importance emerged of some of the comparative studies.

Finally, in the preparation of this volume we have received invaluable help from many friends and colleagues. We would like to thank the London staff of Plenum Press, particularly Joanna Lawrence, for their support, encouragement, and expert advice. We would also like to thank our secretarial and support staff, particularly Elise McCorriston and Florence McGarrity, without whom none of this would have been possible.

William R. Ferrell  
Uwe Proske

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